COESAM/PDFC-89/08

GENERAL DESIGN MEMORANDUM

GULFPORT HARBOR

MISSISSIPPI

DESIGN MEMORANDUM NO. 1

APPENDIX E

THIN-LAYER DISPOSAL

US Army Corps
of Engineers
Mobile District

JUNE 1989

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of a one year monitoring program of the impacts associated with the thin-layer disposal of 50,000 cubic yards of new work dredged material in Mississippi Sound. The object of thin-layer disposal is two fold: 1) the placement of dredged material in open water in a layer 12 inches thick or less and 2) reduction of short term impacts to the aquatic ecosystem.

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20. ABSTRACT (Continued)

Results of this montitoring program indicate that:

1) It is possible to control lift-thickness during open water disposal.

2) Recovery of benthos following a December disposal operation begins as early as 6-weeks post disposal and by 20-weeks post disposal abundances within the disposal area are similar to non-disposal areas.

3) Recruitment to the disposal area, following the December disposal, was mediated by adult migration, followed by spring larval settlement.

COESAM/PDFC-89/08

Monitoring Environmental Impacts Associated with Open-Water Thin-Layer Disposal of New Work Dredged Material at Gulfport Harbor, Mississippi

FINAL REPORT

U.S. Army District, Mobile
Mobile, Alabama

24 June 1988

FINAL REPORT

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1.0 INTRODUCTION

1.1 BACKGROUND

The navigable waterways of the United States have played a vital role in the nations economic growth through the years. In order to fulfill its mission to maintain, improve and expand these waterways, the Corps of Engineers must dredge and dispose of large quantities of sediment each year. The quantity of dredged materials averages about 290 million cubic m annually (Francingues 1985). The disposal of these materials in an environmentally acceptable manner is one of the first priorities in any dredged material management strategy.

The disposal alternatives for uncontaminated dredged materials include open water disposal, confined (upland) disposal or alternate beneficial uses of the dredged material. The use of all three alternatives is considered the best long-term management strategy when developed in concert with other federal, state and local agencies.

In recent years, increased utilization of lands in coastal areas for recreational, industrial, military and energy developments has resulted in a tremendous demand for lands located in adjacent coastal areas. At the same time, existing dredged material disposal sites are reaching their capacities. Thus, while the amount of dredged material requiring proper disposal is increasing, the availability of suitable upland sites is declining. As a result, open-water disposal is the most cost effective strategy in many coastal situations. In order to minimize the environmental impacts of such a strategy, alternate techniques of open-water disposal need to be investigated.

One such method, called "thin-layer" disposal, has been identified as a possibly favorable open-water dredged material disposal technique from both the economic and ecological viewpoints. This method involves the controlled dispersion of dredged material over a large area of water bottom which reduces the bathymetric and hydrologic impacts to the system and thus minimizes impacts on biological resources. It is assumed that recovery from such a disposal technique would be rapid since the disposal would resemble natural seasonal or other periodic events such as storms, spring freshets, frontal passages and hurricanes that disturb the benthic environment and move sediments.

This final report presents the findings of investigations on a thin-layer disposal operation at Gulfport Harbor, Mississippi during 25-26 December 1986 and the physical, chemical and biological conditions in the disposal area both before and up to 52 weeks after the disposal operations. The results of this study, along with the results of a similar study at Fowl River Alabama, will provide information useful in determining the advantages and disadvantages of this disposal technique.

1.2 OBJECTIVES OF THE STUDY

The objectives of this study were to monitor the physical, chemical and biological changes that occurred as a result of the disposal activities and assess the impacts of these changes on biological resources in the disposal area (Figure 1.1-1). To accomplish these objectives required the integration of several techniques commonly used in various disciplines of environmental sciences.

In order to become an acceptable method for dredged material disposal, many questions must necessarily be answered. These include questions on 1) the physical impacts of the disposal operation and the effectiveness of the dredging system in achieving the desired "thin-layer" effect; 2) changes in water quality during the dredge material disposal operation; 3) impact to the bottom dwelling community by the dredge disposal perturbation; and 4) the effect on the fisheries resources in the vicinity of the disposal operation. Specifically, this contract was to (a) measure and characterize disposal-induced suspended sediment fields as compared to ambient conditions; (b) assess changes in sediment characteristics resulting from thin-layer disposal; (c) evaluate the effectiveness of the particular dredge plant used in attaining a uniform "thin-layer" overburden; (d) determine the areal extent of overburden and changes in distribution of disposed material through time; (e) determine the persistence of the overburden through time; (f) assess the impacts of disposal on the benthos; (g) establish the rate

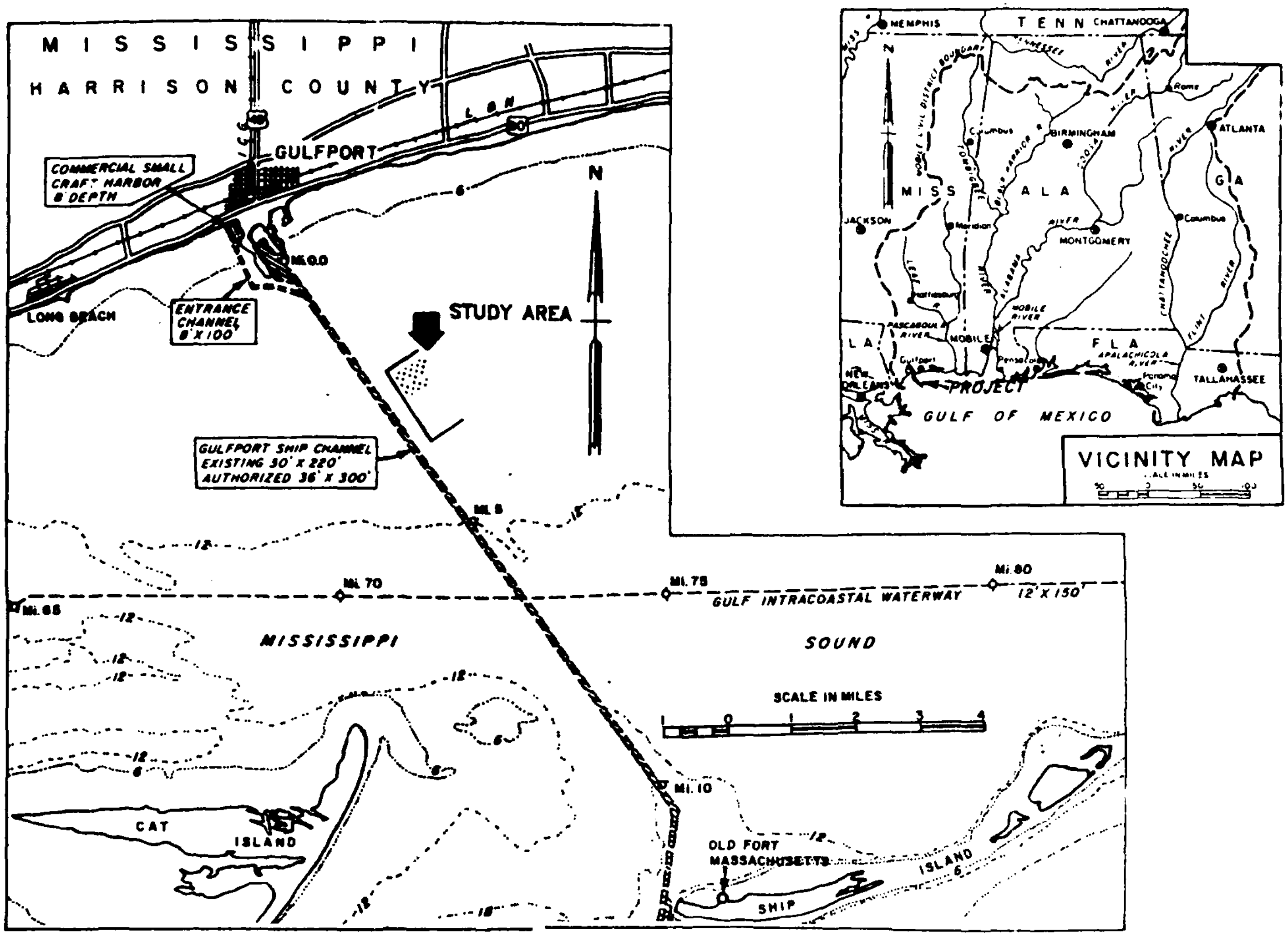


FIGURE 1.1—1. GULFPORT HARBOR STUDY AREA.
(Adapted from COE, Mobile District)

and method of recovery of the benthos to pre-project conditions; and (h) determine whether or not utilization by fisheries resources differs in the disposal area as compared to surrounding reference areas (U.S. COE 1986). Bathymetric surveys were conducted both before and after dredging operations to quantify the change in sediment depth and the areal extent of coverage. This information was used to evaluate the efficiency of the thin-layer disposal methodology by directly measuring the extent of the overburden and observing the changes in the overburden materials over time.

Ambient water quality conditions were determined during a predisposal survey conducted two weeks prior to the dredging operation. A second water quality survey was planned during the dredging operations but was not completed due to several difficulties. These difficulties included 1) an underestimate of the amount of time required for the dredging activities to be completed, 25 hours actual vs. 72 hours estimated; 2) poor communication between dredge operator and contractor before dredging commenced; and 3) lack of communication with the dredger and contractor during Christmas day.

Changes in the resident benthic macroinfauna community are often used to assess the impacts associated with environmental perturbations. Because of their short lifespan and their relatively sessile nature, the organisms which make up this community are a good indicator of the integrated changes in the physical, chemical and biological environment over a period of one to several weeks. Thus, studies investigating the impact of the dredging operations on this community were performed. Specifically, sampling programs for this project were designed to determine 1) how is the benthic community impacted both qualitatively and quantitatively; 2) how long does recovery take; and 3) what portion of benthic community recovery is due to upward migration of the existing organisms and what portion was due to recruitment of juvenile organisms by post-larval settling from the plankton and recolonization from adjacent undisturbed areas. The role these interaction plays in system recovery will thereby be evaluated.

In order to insure that the macroinfauna infauna community sampling adequately detected impacts from the dredge operations, two sampling strategies were used. The first utilized the classical technique which consisted of dividing the study area into 3 areas (1) a reference area surrounding the site to receive the dredged material, 2) the area actually used for the disposal and 3) an area intermediate to the disposal and reference area referred to as the fringe area) and taking an equal number of replicate cores (8) at two randomly selected stations within each sampling area. The second technique consisted of placing a fixed grid of 60 stations which were occupied for each predisposal and post-disposal sampling event. Comparison of the techniques provided insight into the adequacy of the sampling methodologies for detecting impacts due from disposal operations.

Vertical sediment profiling, the technique of taking cross-sectional *in-situ* images of sediment layers can provide the best quantitative data on the success of the thin-layer disposal operation at meeting the design criterion of a nominal 6-12 inches of dredged material thickness. The sediment profile camera is capable of profiling a maximum of approximately 8" (20 cm) of sediment and can detect layering of sediments on the order of millimeters, thereby providing a highly detailed record of the dredge overburden. Application of this technique to the disposal operation at Gulfport Harbor has provided detailed information on the extent and coverage of the operation.

Fisheries studies were conducted to assess the changes in the utilization of the of the disposal area by fisheries resources. Fish data also provide a useful comparison to benthic macroinfauna since fishes are a highly motile and comparatively transient part of the faunal community utilizing the study area. This assessment encompassed both the vertebrate and invertebrate demersal organisms, as collected in trawl samples, and was used to determine the impact of the operation on this valuable resource.

Each of the separate objectives has provided useful data that may be used to evaluate the environmental impacts associated with open-water thin-layer disposal. As a whole, they provide a comprehensive picture of the overall effects and integrated changes of the physical, chemical and biological aspects of the Gulfport Harbor disposal site.

2.0 METHODOLOGY

2.1 PHYSICAL/CHEMICAL ENVIRONMENT

2.1.1 Bathymetry Surveys

Bathymetric surveys were conducted both before and after dredged material disposal operations to quantify the rise in sediment depth and areal extent of sediment deposition. These data were used to evaluate the efficiency of the thin-layer disposal methodology. In addition, results of the bathymetric surveys were used to evaluate changes observed in the community structure of both benthic macroinvertebrates and fishes in the disposal and fringe areas.

Bathymetric surveys were conducted in the disposal , fringe and reference areas of the Gulfport Ship Channel open water disposal site (see Figure 2.1-1). Sounding lines were placed at 100-foot (ft) intervals oriented in a northwest-to-southeast direction, extending into the reference areas. Five perpendicular lines were run to check the accuracy of depth data. Depth measurements were taken at 25-ft intervals.

A total of four bathymetry surveys were conducted: one predisposal survey 2 weeks prior to initiation of dredging and three post-disposal surveys 2, 6, and 20 weeks after termination of dredging. Water depths were measured with a Raytheon Model DE-719B fathometer. The DE-719B is a survey-grade fathometer capable of operating in depths between 2 and 410 ft. Given the depth of the study area (9 to 11 ft), the DE-719B was accurate to within +/-0.2 ft. The fathometer was calibrated at the beginning of each day, as well as periodically thereafter as needed. The calibration was accomplished with a graduated sounding line equipped with an acoustic target. The fathometer was equipped with a narrow-beam transducer, tide and draft adjustment, and speed-of-sound compensation to ensure accurate measurements with high resolution.

A Del Norte Model 202-MS20 Trisponder Navigation System (DTNS) was used to continuously determine the boat's position during each survey. DTNS is a microwave positioning system that is accurate to +/-3 ft. The system uses triangulation position fixes based on distances from two (or more) shore-

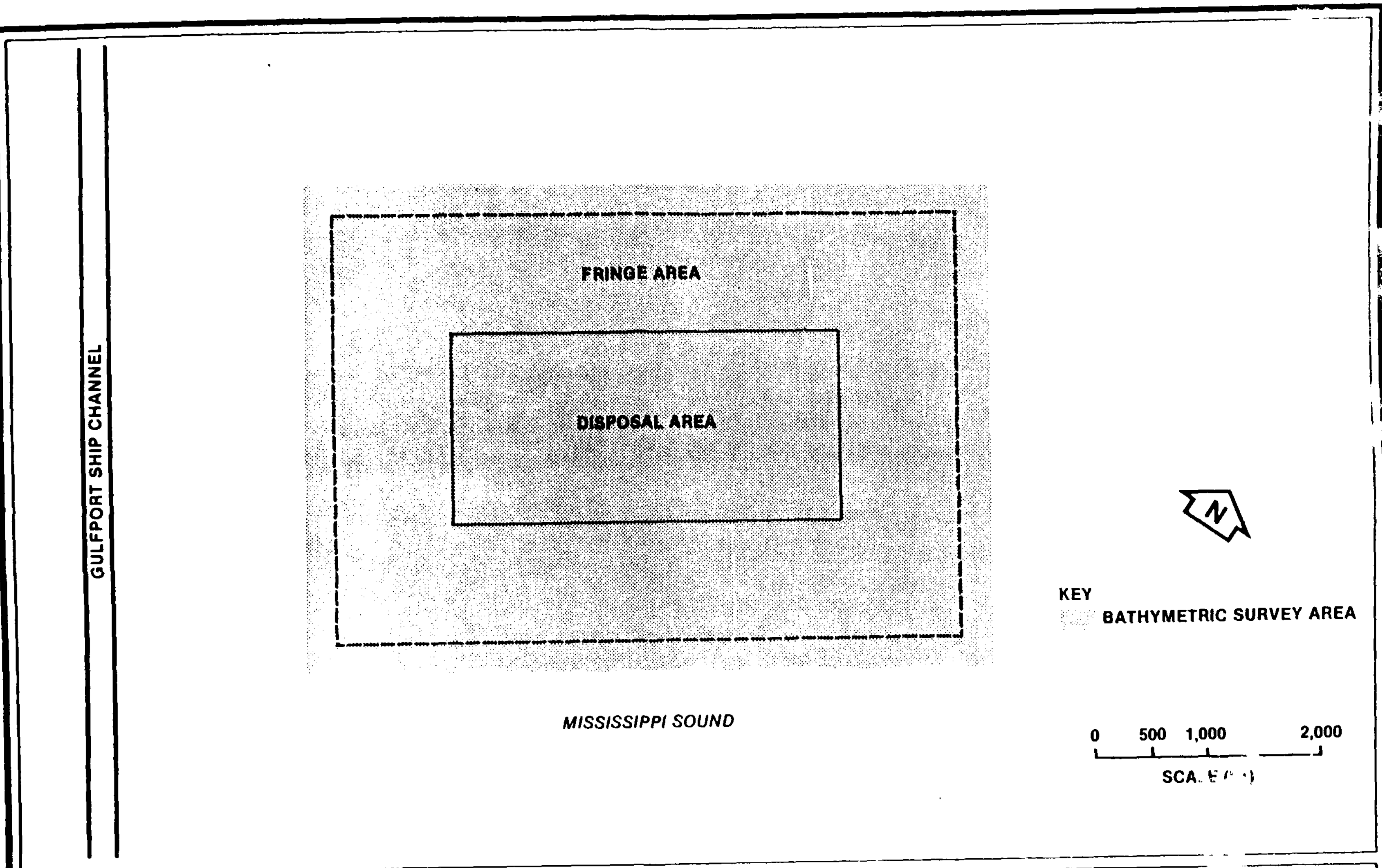


Figure 2.1-1
LOCATION OF BATHYMETRIC SURVEY AREA

based reference stations. A total of three shore-based reference stations were used during surveys at the Gulfport Ship Channel Study Site. Because this study required not only precise depth readings but precise position information as well, each of the shore-based reference stations was located at a benchmark with known horizontal control. Since precise transect lines were also required for this study, the DINS was interfaced with an Autocarta real-time positioning and recording system. The Autocarta system consisted of a microcomputer, helmsman left/right display, data terminal, and magnetic tape data recorder. Both the fathometer and Del Norte navigation system were interfaced with the Autocarta system to provide completely automated data collection. Using this system, the transect grid was preprogrammed prior to the first survey. The vessel operator then followed the pre-established grid lines using the helmsman's left/right display, ensuring the transect lines were spaced properly at 100-ft intervals.

Position fixes, depth, and real time were automatically recorded on magnetic tape by the Autocarta system. Data points consisting of depth, position, and real time were recorded at 25-ft intervals along each of the survey lines. To allow comparison of one set of bathymetric data to another, depth readings were referenced to National Ocean Survey (NOS) Mean Low Water (MLW). Because actual water levels at any given time are a function of tides, winds, barometric pressure, and other factors, the use of predicted tides from the NOS Tide Tables would be insufficiently accurate for adjusting recorded depths to MLW. Therefore, a continuous recording tide gage was installed at Gulfport Harbor to provide site-specific water-elevation data. A Leupold-Stevens Type A Water Level Recorder was used to continuously measure actual tide data during the bathymetric surveys. Water-elevation data also were obtained from the Harrison County Civil Defense Council, located in Gulfport, Mississippi. The Civil Defense Council operates a network of water-elevation monitoring stations, with one site located at Gulfport Harbor.

All bathymetric data were processed using Environmental Science and Engineering, Inc.'s (ESE's) automated data handling system. In the office, data consisting of depth, position, and time were transferred from magnetic tape directly to a personal computer. The water depths were then adjusted to MLW based on water-level data collected by the water-level recorder located at Gulfport Harbor. This new data file was then transferred to ESE's Prime 750 computer and subsequently transferred to the North East Regional Data Center (NERDC), located at the University of Florida, where the contouring package Surface II was used to produce the bathymetric contours presented in Section 3.0 of this report. Areas of sediment deposition equal to or greater than 0.5 ft were measured using a planimeter.

2.1.2 Water Quality

Water quality investigations were conducted to assess the impact of dredging operations on dissolved oxygen (DO), salinity, temperature, total suspended solids (TSS), and current speed and direction. Ambient water quality conditions were determined concurrent with the predisposal bathymetric survey conducted 2 weeks prior to the initiation of dredging. A second water quality survey was to be implemented during dredge disposal operations. However, due to logistical problems, described in the introduction, the second water quality survey could not be carried out.

Prior to dredging, a sampling grid consisting of eight evenly spaced water quality stations was located within the disposal site (see Figure 2.1-2). DINS was used to identify the exact location of all stations. A control station was located 2,400 ft up the bay, north of the disposal area, with another control station located 2,400 ft east of the disposal area. All 10 stations were sampled a total of 12 times, 6 during ebb and 6 during flood tide. Measurements were taken at four depths (5, 50, 80, and 95 percent of total water depth) at each station. DO, specific conductance, and temperature were measured at each of the four depths at all 10 stations using a Hydrolab 4041 water quality monitor. All meters were calibrated according to manufacturers' instructions at the beginning of each field day. Salinity was later calculated using specific conductance values obtained in the field. All measurements were accurate to within 0.1 degree Celsius (°C) for temperature, 0.1 parts per million (ppm) for DO, and 0.1 parts per thousands (ppt) for salinity. Current direction and velocity were measured

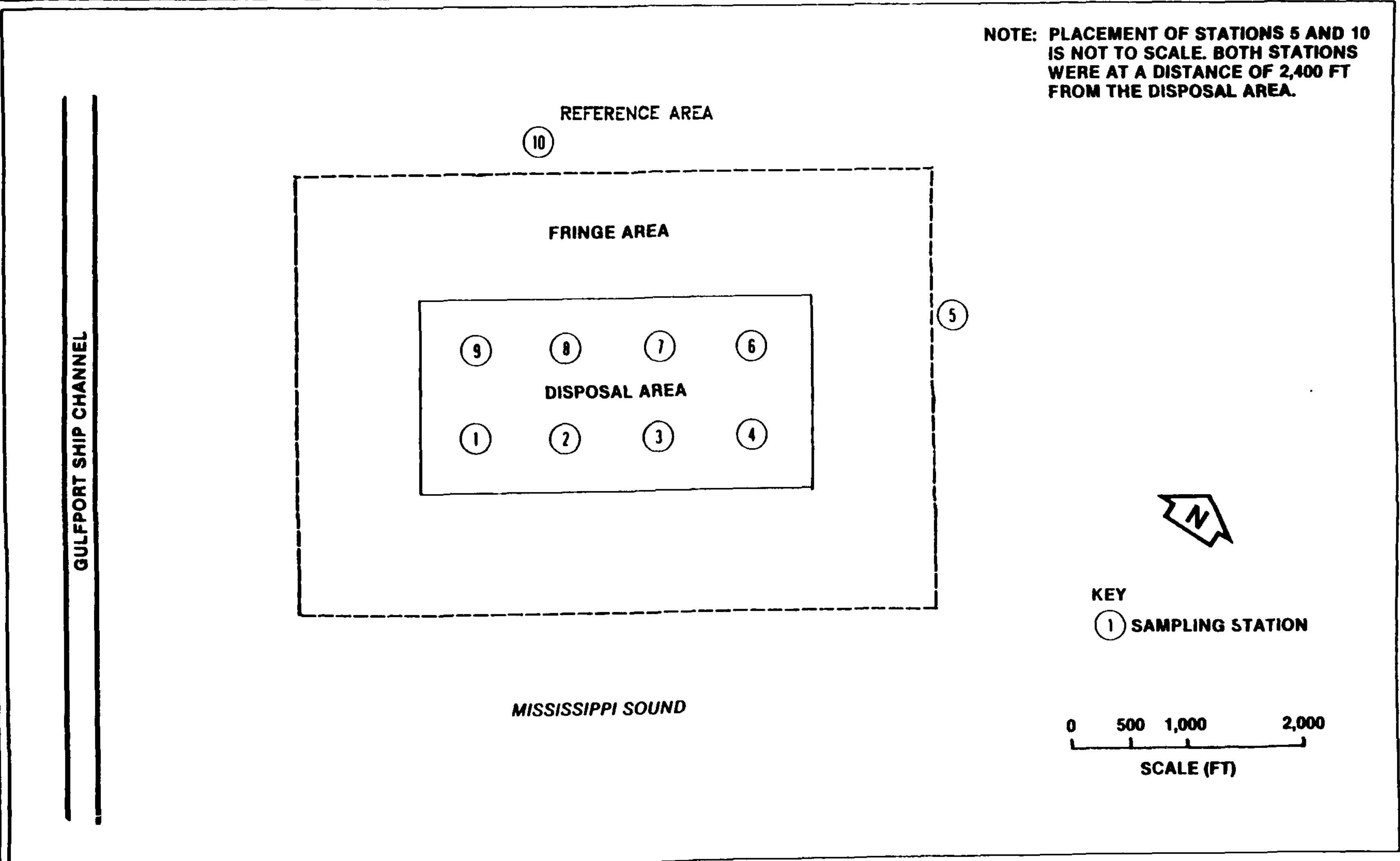


Figure 2.1-2
PREDISPOSAL WATER QUALITY SAMPLING STATIONS

using an ENDECO 110 current meter. Discrete water samples of 250 milliliters (ml) each were taken from all four depths at each of the 10 stations. Samples were returned to ESE's laboratory in Gainesville, Florida, and analyzed for TSS. All water samples were collected using a Jabsco electric diaphragm pump and maintained at 4°C from the time of sample collection until analysis. A flexible hose from the water pump was attached to the Hydrolab probe housing to provide accurate depth measurements for TSS samples. All TSS samples were analyzed within the required 7-day holding time.

2.1.3. Vertical Sediment Profile Imagery.

Vertical sediment profile imagery was obtained at each of the 60 fixed benthic stations and an additional 12 floating stations each sampling period, for a total of 360 images (72 stations x 5 sampling periods). Within each treatment area at 2 randomly selected stations 3 replicate images were collected during each sampling period for a total of 90 images (2 stations x 3 areas x 3 reps. x 5 sampling periods). A modified Benthos Model 3731 Sediment Profiling Camera was used to obtain all images and the International Imaging Systems Model 75 image processor to interpret and analyze the images (see Table 2.1-1).

Since the main objective of the Benthic Profiling Task was to document the thickness of placed material and impacts of the disposal operation we used both color slide (Kodachrome) and Black and White (Pan-X) film. The color film provided the best contrast for identifying the dredged material layers, and also the RPD boundary. The image analysis was done in color since the tonal qualities of Kodachrome film far exceed those of any black and white film, better matching our image processing capabilities. The color film also allowed for a much more detailed visual evaluation of dredged material thickness and general environmental conditions. The main advantage of black and white film was in cost of reproduction of images for reports. TAI used color film at half the stations, and black and white film at the other half of the stations.

From every station two 8 x 10" positive prints from black and white or two slide copies from Kodachrome film were made and delivered to the contracting

Table 2.1-1. Modifications made to Benthos Inc. sediment profile camera.

Modification	Reason
Replaced standard Olympus 50 mm lens with a 50 mm macro lens.	To improve image clarity, particularly at the edges of the image.
Placed a bubble level within the prism to show on each image.	To provide a level reference point so surface roughness and bed forms, can be accurately interpreted.
Illumination of the surface immediately in front of the prism window with a Slave Strobe.	To provide increased detail of surface features near the prism window.
Mounted a Benthos 372 camera and 382 Strobe on the sediment profile frame to provide separate surface images for evaluation of surface features.	Sediment profile images do not consistently record surface features. If the prism penetrates below the optical axis of the camera (a depth of about 10 cm) surface features cannot be seen with any consistency.

officer. An additional copy was retained by the contractors for future analysis and interpretation. The information obtained from sediment profile images was, at a minimum, all those parameters listed in Table 2.1-2. All images from each sampling period were processed, interpreted, and an interpretive interim report was written within 30 days after the completion of each field sampling effort. This report, as a minimum, contained a narrative interpreting each of the parameters measured, tables of all measurements made, station numbers and locations, and date and time of sampling.

Table 2.1-2 Image Analysis Measurements from Sediment profile.

Measurement	Method	Usefulness
a - Depth of Penetration	Average of maximum and minimum distance from sediment surface to bottom of prism window	Penetration depth is a good indicator of sediment compaction.
b - Surface Relief	Maximum minus minimum depth of penetration	If the camera is level this is a good measure of small scale bed roughness, on the order of 15 cm (prism window width).
c - Digitized Image Statistics 1. Range of pixil densities for total image 2. Range of pixil densities for areas of interest	Actual range of densities the digitizing camera detects from the Sediment profile image	For cross comparisons of images it is necessary to have any measurement relying upon image pixil density to be done on similar intensity ranges.
d - Depth of RPD layer	Area of oxic layer (g) divided by width of prism window. Maximum and minimum distance from sediment surface to top of RPD layer are also measured	Gives a good indication of DO conditions in the bottom waters and the degree of bioturbation in muddy sediments. In sands will be related to porosity and turbulence.
e - Color contrast of RPD	Contrast between oxic and anoxic layers is determined from density slicing of digitized image	Establishes boundary of RPD and depending upon whether the RPD is straight or convoluted will be useful in understanding the biologic and physical process

Table 2.1-2. (Cont.)

Measurement	Method	Usefulness
f - Area of anoxic layer (below RPD)	Select desired pixil density for boundary between oxic and anoxic, count pixils, and convert pixils to area	When calculated to a constant depth of penetration and combined with oxic layer area a good understanding of RPD dynamics can be obtained
g - Area of oxic layer	Total area of image minus area of anoxic layer	When calculated to a constant depth of penetration and combined with oxic layer area a good understanding of RPD dynamics can be obtained
h - Feeding Voids	Number counted, depth from surface of each measured, area of all voids delineated	Void presence is a good indicator of deep living fauna and later successional stages
i - Other inclusions (methane, bubbles, mud clasts, shells)	Number counted, depth from surface of each measured, area of all voids delineated	Often other inclusions such a methane or mud clasts are common in images. These are very helpful in understanding recent physical processes
j - Burrows	Number counted, area delineated	Burrow presence is a good indicator of deep living fauna and later successional stages
k - Surface features		Presence of these features is indicative of recent biologic and physical processes
1 - Tubes	Counted and speciated	
2 - Epifauna	Counted and speciated	
3 - Pelletized layer	Thickness and area delineated	
4 - Shell	Qualitative estimate of coverage	
5 - Mud clasts	Qualitative estimate of coverage	

Table 2.1-2. (Cont.)

Measurement	Method	Usefulness
l - Sediment Grain Size	Determined from comparison of image to images of known grain size	Provides rough estimate of grain size and sediment layering
m - Dredged Material Layers	Measure thickness above original sediment surface and area delineated	Location of dredged material and measuring its thickness are centered to the entire monitoring effort and will be the best quantitative measure for relating impacts to benthos
n - Successional Stage	Combination of measurements and interpretation of key image features (d, g, h, i, j, k)	Measure of biological community development

2.2.0 BIOLOGICAL RESOURCES

2.2.1 Benthic Macroinfauna

The outcome of any technical investigation is limited by its initial design. In environmental monitoring studies, such as the subject of this report, the statistical design selected at the beginning of the project will determine the resolution of the analyses ultimately performed on the data. Some knowledge of the variability of each of the parameters studied must be known in order to select the appropriate sampling frequency and the proper number of replicates. Further discussion is provided at the end of this section.

Benthic macroinfauna samples were taken from 60 fixed stations located within the COE designated sampling area (Figure 2.2-1). Since it was critical that the relationship between the sediment profile photos described in the sediment profiling section below and the benthic macroinvertebrate samples obtained be precisely delimited, all benthic samples were located in a manner that allowed for subsequent statistical analysis between the macroinfauna and the sediment profile images. One concern was the physical impact the sampling would have on the bottom. For example, deployment of the sediment profile unit disturbed approximately 25 square feet of bottom. Both the macroinvertebrate sampling and the sediment profile sampling impacted the area, and this impact may have been detectable in subsequent samplings if precautions were not taken. In order to avoid the inclusion of sampling artifacts in the data, the following sampling procedure was implemented. A fixed site was designated as an area of 6 x 6 meters (36 m^2) with a fixed center. One sample was taken with a box core sampler with a .25 square meter coverage at each station as fixed by the Del Norte range finder system. Only one replicate was taken at the sixty fixed stations. Each sample was then gently sieved with a bucket containing 500 micron mesh screening.

In addition to the fixed sampling described above, a random sampling for benthos was also performed. During each sampling period, eight box core samples were taken at each of 2 randomly selected stations with each sampling strata (disposal, fringe and reference areas).

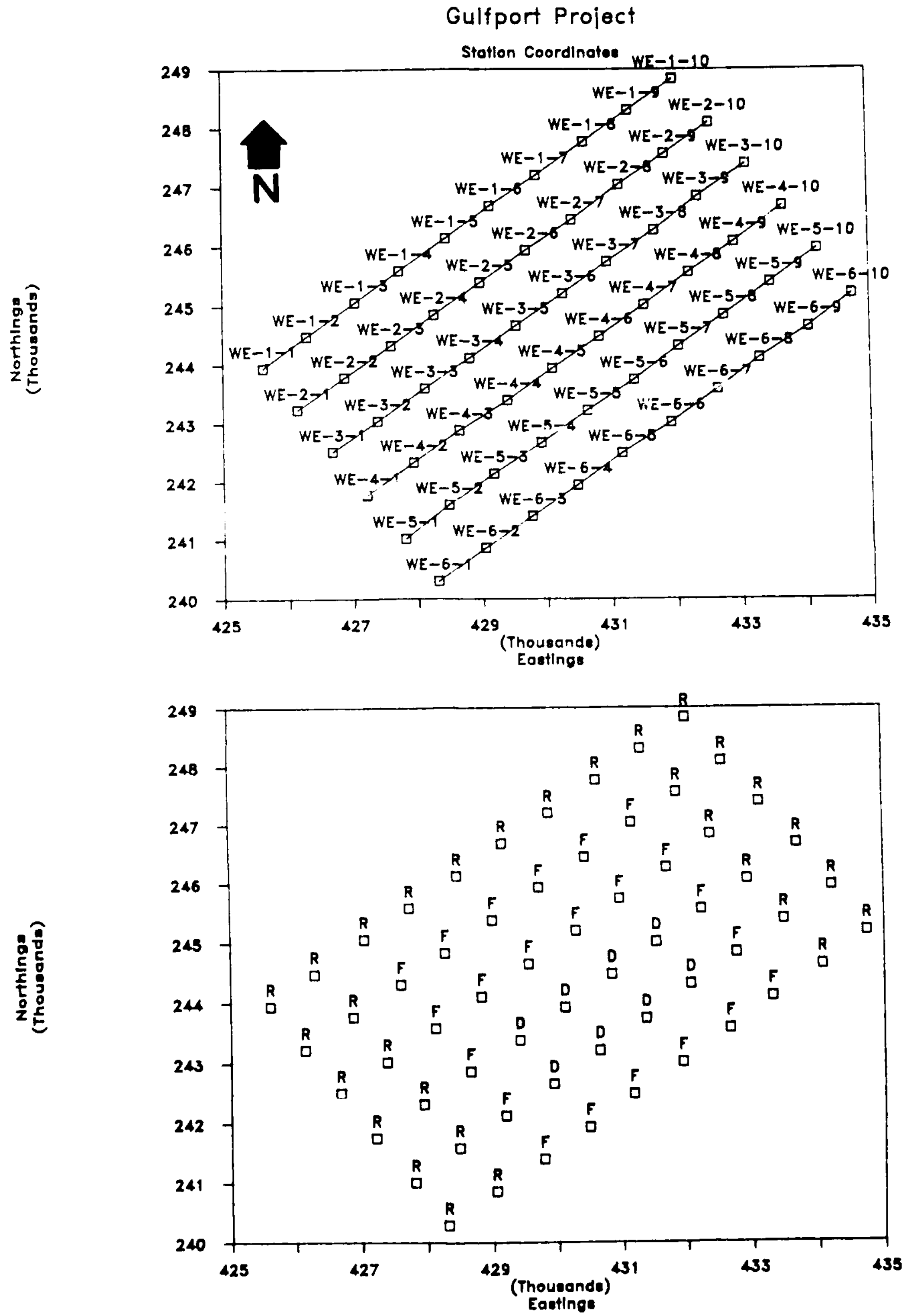


FIGURE 2.2-1. FIXED STATION DESIGNATIONS FOR THE GULFPORT HARBOR THIN-LAYER STUDY. CHANNEL LIES TO THE SOUTHWEST OF AREA. R=REFERENCE, F=FRINGE & D= DISPOSAL AREAS. WE = WEST-EAST Line Numbers.

The samples were relaxed in the field by cooling the sieved samples down to 4° C. Upon return from a days sampling effort, the organisms and associated detritus were preserved in a 10 percent seawater-buffered formalin-rose bengal solution. This method has proven to be most effective in preventing organism fragmentation.

In the laboratory, initial separation of preserved-stained organisms was accomplished using a lighted magnifying lens. This was followed by separation into size classes by gently washing the organisms through a series of stacked sieves of 6.5, 3.5, 2.0, 1.0 and 0.5 mm mesh sizes. Samples then underwent a final sorting into major phylogenetic groupings before taxonomic identification was begun.

Identification of the fauna was to lowest practical taxonomic level, usually to the species level, and was done, prior to weighing, on every wet weight biomass fraction. Voucher specimens were then sent to appropriate taxonomic referees. Upon completion of all primary and secondary identifications, samples will be returned to the U.S. Army Corps of Engineers for proper disposition.

All macroinfauna were divided into major taxonomic groups, within their respective size classes, and weighed for wet weight biomass after processing for taxonomic identification was completed. Since the organisms had been stored in alcohol prior to analysis, some osmotic dehydration of the organisms was expected, and was considered to result in a constant negative error in the wet weights as compared to living tissue. All organisms were removed from their storage vials and blotted dry with filter paper prior to weighing. Special care was taken to ensure that samples were not damaged by handling and desiccation exposure during the weighing process. All weights were determined with a Mettler model AE163 analytical balance with a readability of 0.01 mg and a reproductibility of +/- 0.02 mg. All measurements were recorded to 5 significant decimal places. All weights were combined for reporting purposes and averaged over the entire sampling strata.

In addition to the previous analyses, the presence and possible impact of recruitment was addressed. The use of a 0.5 mm sieve cannot adequately follow the early recruitment events of the settling of post-larval fauna. To better understand recruitment patterns between treatment areas, a 10 cm diameter by 2 cm deep core was taken from an additional sample collected with the boxcore dredge from 30 of the fixed benthic stations occupied and washed through stacked 0.5 and 0.25 mm sieves. Each fraction was relaxed in the field with ice, and later preserved with rose bengal-formalin when returned to the laboratory for processing. In the lab, the 0.5 mm fraction was rough sorted, weighed for biomass determination and archived for possible future processing. The 0.25 mm fraction was processed to the lowest practical taxonomic level, usually to the genus or family level. Biomass of the 0.25 mm fraction was then estimated at all stations. Since the organisms in the 0.25 mm sample are so small, a biomass conversion factor was determined for each major taxonomic group and applied to the total number of individuals in a sample.

A subsample for sediment grain size analysis was also taken at each of the 60 benthic stations with a 2.5-cm diameter core tube. Only the top 5 cm was subsampled for analysis. All samples were then processed for grain size analysis.

Reports of the benthic data include standard taxa tables with summaries of individual species, major taxonomic groups and station summaries including total number of organisms, total number of species, mean number of organisms, 95 percent confidence limits and Shannon-Wiener diversity.

The entire sampling regime for the project was based on a statistical design to test the hypothesis that there are no differences in any of the parameters between the disposal, fringe and reference areas. The three areas then followed a two factor design with interaction. The two factors tested were sampling area (disposal, fringe or reference), a spatial factor, and sample period (pre, post 2 weeks, post 6 weeks, post 20 weeks and post 52 weeks), a temporal factor.

The statistical analysis performed on the macroinfauna samples was divided into three major sections: a) descriptive statistics; b) analytical statistics and; c) classification, ordination and response surface analyses. Descriptive statistics are those that describe the nature of the data (mean, standard deviation, standard error) and determine whether the data meet the requirements of other statistical tests to be performed (skewness, kurtosis and normality). Analytical statistics are those that test a hypothesis utilizing probability statistics such as whether two means differ significantly or whether a relationship between two variables is significant. Classification, ordination and response surface statistics are useful in illustrating community responses to changes in environmental variables and integrate complex relationships into more manageable and therefore more understandable display. The BMDP (Dixon 1983) statistical software package, running on an IBM-XT was utilized for univariate and analytical statistics. Two-way analysis of variance for repeated measures (BMDP-P2v) was applied to the data from all sampling periods to test for spatio-temporal differences.

Descriptive statistics were performed on an IBM-XT and AT microcomputer utilizing commercially available packages called Symphony (TM) and dBase III. Additional descriptive statistics were performed utilizing C programs written for an IBM microcomputer (diversity indices). Cluster analyses and Ordination analyses were performed using programs developed by Taxonomic Associates.

Q and r-mode Cluster analyses were performed on the macroinfauna abundance data. The Q-mode analyses were performed to compare similarities between stations. Separate runs were performed with the operational taxonomic units (OTUS) representing each station in the 60 fixed-station grid (60 OTUS). The r-mode analyses were performed to allow for community comparisons (relationships between species) between the sampling strata and between sampling periods. All runs were performed using the dissimilarity measure with flexible sorting.

Both Q-mode (stations are the operational taxonomic units (OTUS)) and r-mode (species are the OTUS) clustering were applied to each of the monitoring periods. In order to view the resulting dendrograms for this study in a meaningful format, it was decided that a single similarity index would be used for the plots. Since different indices result in variable dendrograms and hence interpretations, several were applied to the Gulfport database and a combinations of indices and clustering techniques were used. Based on the results of these preliminary analyses, a constant set of statistic parameters were selected.

In many resemblance measures (such as Bray-Curtis), attributes (species) with large scores generally overweigh an analysis, whereas less abundant species are rendered relatively unimportant. The Canberra metric minimizes some of the effect of predominant species on quantitative cluster analysis. It has been used in aquatic ecological studies (Boesch 1977) and because of its characteristics has been chosen for use in this study.

Flexible sorting with a beta value of -0.25 was used to minimize the "chaining" effect in the dendrograms. This has produced satisfactory results in a wide range of data sets and has been used in several marine ecological applications (see Boesch 1977).

Response surface analyses prepared consisted of two and three dimensional displays of species (or appropriate summary taxa) across the fixed 60 station grid.

2.2.2 Demersal Organisms.

Trawling was conducted from a 42 ft shrimp boat (Sam & Elaine). Sampling gear consisted of a 16 ft otter trawl with 3/4 inch bar mesh outfitted with 2 ft boards and a 150 ft bridle.

After the completion of benthic sampling, trawl samples were collected within four designated areas including the disposal area, a fringe area north of the disposal area (north fringe), a fringe area south of the disposal area (south fringe) and a reference area north of the north fringe disposal area (south fringe) and a reference area north of the north fringe area. Within these areas, fixed trawl lines were designated equidistant between each pair of lines formed by the fixed station transects (See Figure 2.2-2). These trawl lines were spaced approximately 750 ft apart and ran on an east-west axis. During trawling operations, buoys were spaced at 300 ft intervals to form a 250 ft safety zone on either side of the random trawl corridor.

During night trawls, fluorescent light sticks were strapped to buoys prior to sampling. Also, during the 2, 6 and 20 week post-disposal field efforts, electric lamps were hung from pvc poles, placed at the fixed stations, for additional reference points. This assured that no overlap occurred between fisheries and benthic sampling areas.

Trawling commenced only after the completion of the benthic and sediment profile tasks and trawl corridors were chosen randomly for each of the five monitoring periods. Trawl distance was standardized to approximately 1300 ft and approximately 2 knots respectively. This assured uniformity of sampling and prevented overlapping between sampling areas.

Sampling was conducted on alternate days, weather conditions permitting, until four sets of samples were obtained. Three replicate samples were collected for each trawl corridor. These sampling periods were divided between daytime and nighttime collections to produce a diel sampling regime, thus yielding twenty-four (24) samples in a given 24-hour cycle. Each field effort, therefore, resulted in the collection of 96 trawl samples. All field efforts were recorded on standardized field note sheets, and are maintained on file for future reference.

Upon collection, samples were immediately transferred to 1/4 inch mesh nylon net bags and placed in a relaxing solution of seawater-buffered 2% formalin. Samples were then returned to the laboratory and placed in a 10% formalin solution for fixation. The abdominal cavity of fishes larger than 20 cm was slit to allow penetration of preservative. Samples were allowed to fix for approximately 10 days, at which time they were transferred to glass jars and

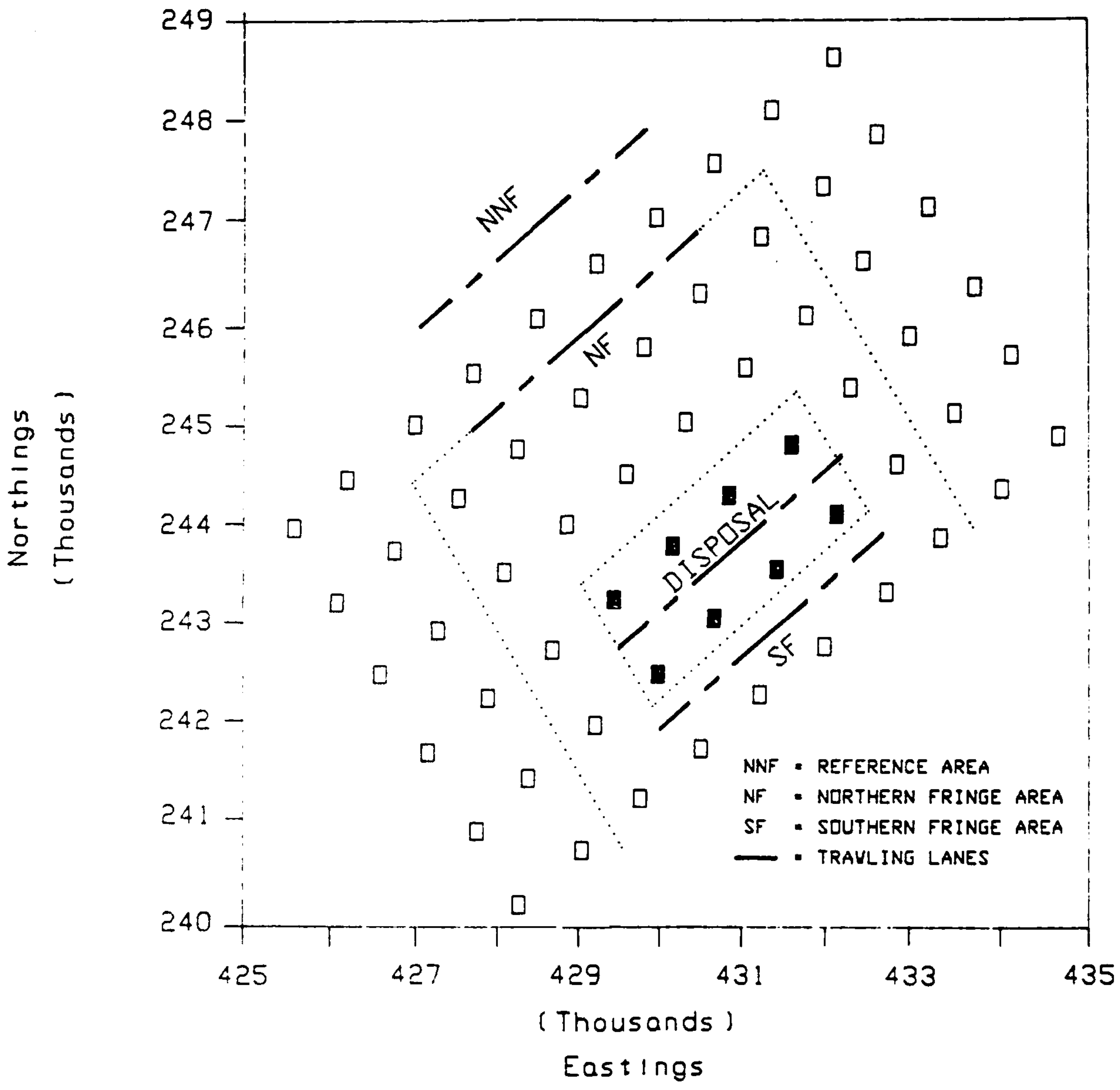


FIGURE 2.2-2 LOCATION OF THE TRAWL CORRIDORS FOR THE GULFPORT HARBOR FISHERIES TASK.

placed in a 40% isopropyl alcohol solution for long term storage. All samples were provided with tyvek labels and marked with permanent indelible ink for long term curation.

All specimens were identified to the lowest practical identification level (LPIL), usually to species, and recorded on standardized taxonomy data sheets. Each specimen, upon identification, was measured for standard length (SL), and recorded to the nearest millimeter. All primary identifications were performed by TAI personnel.

Secondary identifications were performed on a select subsample of trawl samples from each field effort by Dr. Robert L. Shipp of the University of South Alabama. All secondary identifications were then compared to the primary identification data, and any discrepancies were investigated and corrected.

The sampling regime for the fisheries task was designed, as were the previous tasks, to test the null hypothesis that there are no differences between experimental (disposal and fringe) and reference areas (Ho = 0, null hypothesis). The experimental design followed a standardized transect design with replication. No stratification was assumed to exist within each of these areas. This design allows for natural inter-area (experimental vs. reference) variability to be controlled for maximum resolution with the minimal amount of sampling. The three major types of statistical analyses performed were: a) descriptive statistics; b) analytical statistics and; c) classification and ordination analyses.

Size-frequency displays or Hubbsograms (Hubbs & Hubbs, 1953) were prepared to illustrate size frequency data. Analytical statistics were performed utilizing BMDP statistical software for the production of ANOVA tables. The ANOVA tables test a hypothesis utilizing probability statistics such as whether there is a significant difference in means (x) or the possibility of significant inter-variable relationships. Classification and ordination analyses are useful in illustrating community responses to changes in environmental variables. Cluster Analysis, both Q and r-mode, utilizing the

Bray-Curtis resemblance measure with group average sorting, were used to develop similarity indices for the overall sampling designations and major species respectively.

All parameters collected during this study, including aspects of the physical/chemical environment and the biological resources are used in presenting a comprehensive picture of the environmental impacts associated with thin-layer dredged material disposal technology. The integration of the results obtained during this multi-disciplinary investigation will be useful in extrapolating the findings presented here to other areas where this disposal technique is used in the future.

3.0 RESULTS

3.1 PHYSICAL/CHEMICAL ENVIRONMENT

3.1.1 Description of Study Area

The Study site was located south of the Port of Gulfport within the Mississippi Sound, an elongate water body located on the northeastern Gulf of Mexico (See Figure 1.1-1). The major axis of the sound runs east and west and is oriented parallel to the Gulf. A series of barrier islands mark the seaward boundary of the Sound. In the vicinity of Gulfport, Ship Island and Cat Island, which are located toward the western end of Mississippi Sound, separate the Gulf from the Sound.

The tides of Mississippi Sound are predominately diurnal with an averac range of 1.47 feet (45 cm). The tides are modified by the basin bathymetry, winds and river discharge. Sustained south and southeast winds push water from the Gulf into the sound whereas north and northwest winds have the opposite effect (Kjerfve 1982).

Sediments of the sound have been described by Upshaw et al. (1966) who indicated that the bottoms are composed of silt and clay with some fine to medium sands. The current study area was reported by Vittor (1982) to be comprised of sand-silt clay and silty-clay.

The sound is a relatively shallow basin averaging 9.9 feet. On the western tips of the barrier islands slightly greater depths are found, caused by the scouring action of the tides (Eleuterius 1976). Between Ship and Cat Island is the entrance to the Gulfport navigation channel with a authorized project depth of 32 ft. The Intracoastal Waterway spans the east-west axis of the sound and has an authorized depth of 12 feet.

3.1.2 Bathymetry

Four bathymetric surveys were conducted at the Gulfport Ship Channel open-water disposal site to evaluate the effectiveness of the thin-layer dredged material disposal methodology. Approximately 10,000 data points were generated during each of the four bathymetric surveys. Each data point consisted of depth, time, and horizontal position. All water depth data were adjusted to NOS MLW prior to contouring. Bathymetric contours of the study area obtained during the predisposal survey were used to determine the existing topography of the open-water disposal site.

The predisposal bathymetric chart with contour lines at half-foot intervals is presented in Figure 3.1-1. Due to foul weather encountered during the predisposal survey, the eastern-most 600 ft of the fringe and reference areas could not be surveyed. All of the remainder of the reference, fringe and disposal areas and 450 ft of the eastern fringe area were surveyed during the predisposal field effort. The results of subsequent bathymetric surveys showed that all of the area which received dredge spoil was covered during the predisposal survey.

Results of the predisposal survey (see Figure 3.1-1) show the topography of the study area to be relatively smooth, with water depths gradually increasing from approximately 10 ft in the northern fringe area to 11 ft in the southern fringe area. The 10.5-ft contour line was located in approximately the center of the study area in a general east-to-west orientation. There was an overall increase in water depth with increasing distance offshore, at a rate of approximately 1 ft in depth over a distance of 4,000 ft.

A second bathymetric survey, conducted 2 weeks after completion of dredged material disposal operations, showed clear evidence of sediment deposition within the study area (see Figure 3.1-2). The area of greatest sediment deposition (0.5 ft or greater) was centered within the disposal area. A comparison of the predisposal and 2-week post-disposal bathymetric surveys shows sediment deposition to have also occurred in both the northern and southern fringe areas of the study site.

A bathymetric chart showing the areal extent of sediment deposition in the study area was produced by plotting the difference between the 2-week post-disposal and predisposal surveys (see Figure 3.1-3). The weather between these two studies was typical of the December-January period with the passage of a cold front on the 26-27 of December. The study area

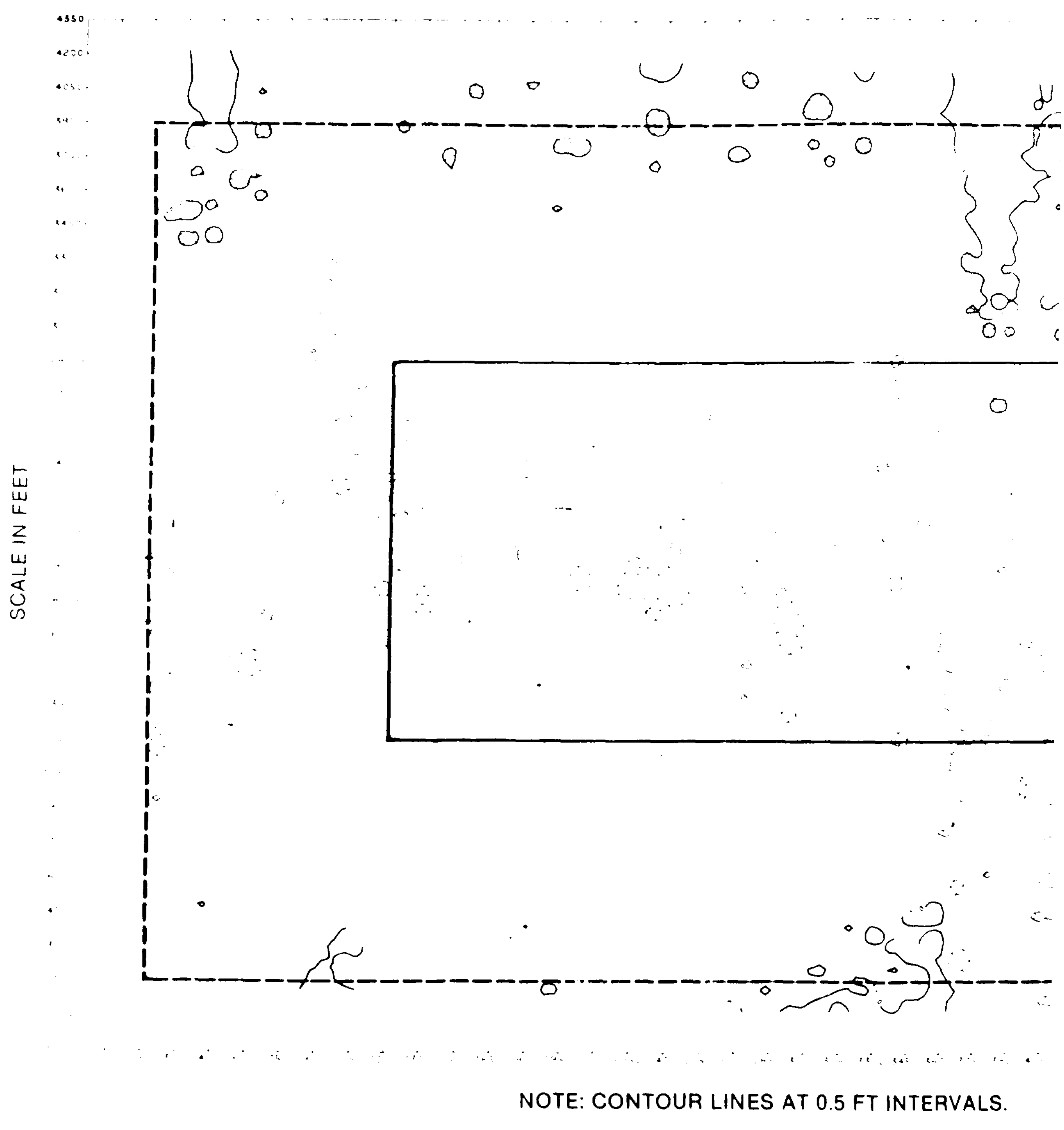
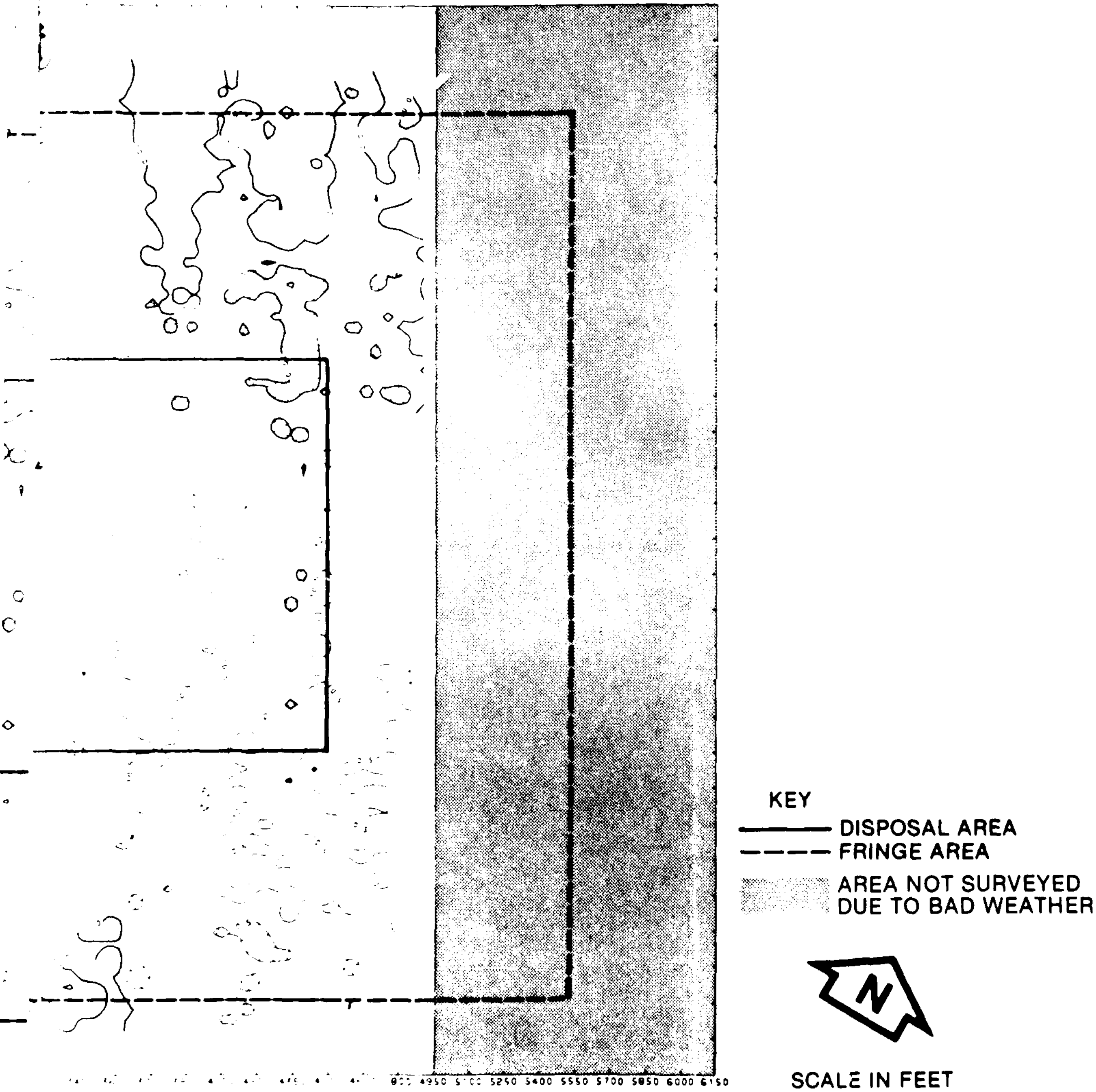


Figure 3.1-1
PREDISPOSAL BATHYMETRIC SURVEY, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.


KEY
DISPOSAL AREA
FRINGE AREA
AREA NOT SURVEYED DUE TO BAD WEATHER
N
4950 5250 5400 5550 5700 5850 6000 6150
SCALE IN FEET

T INTERVALS.

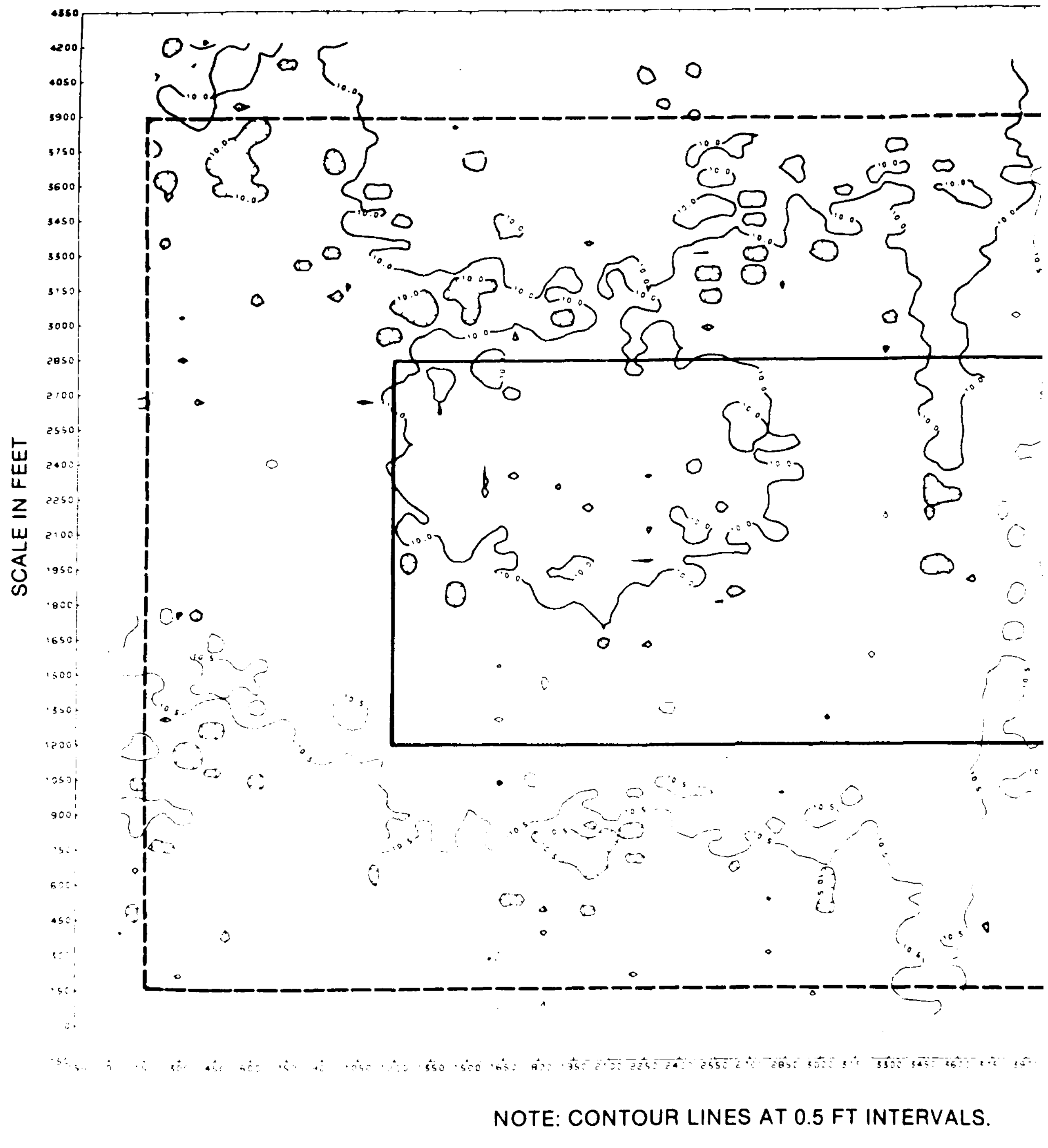
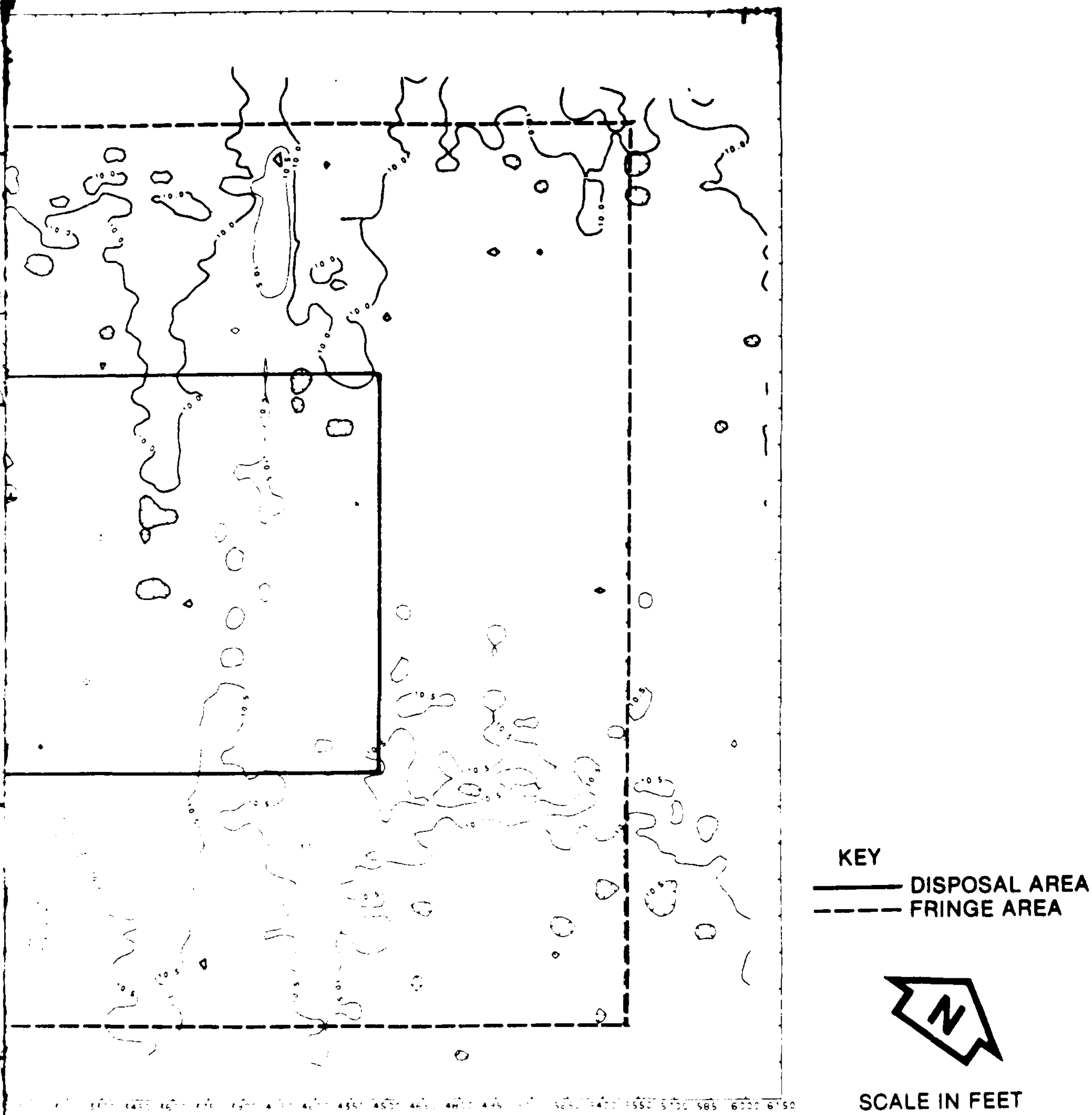


Figure 3.1-2
TWO-WEEK POST-DISPOSAL BATHYMETRIC SURVEY, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



. 5 FT INTERVALS.

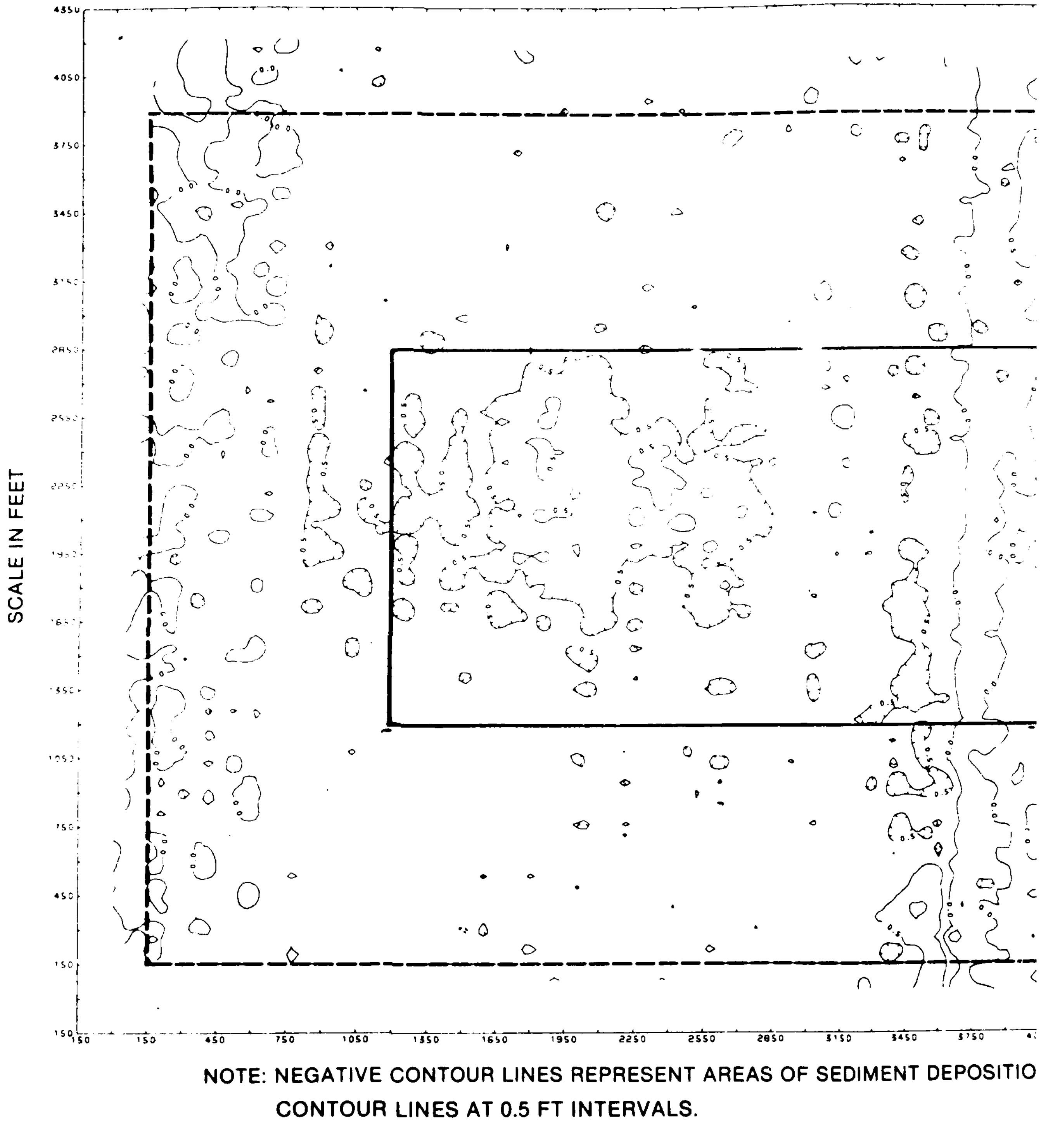
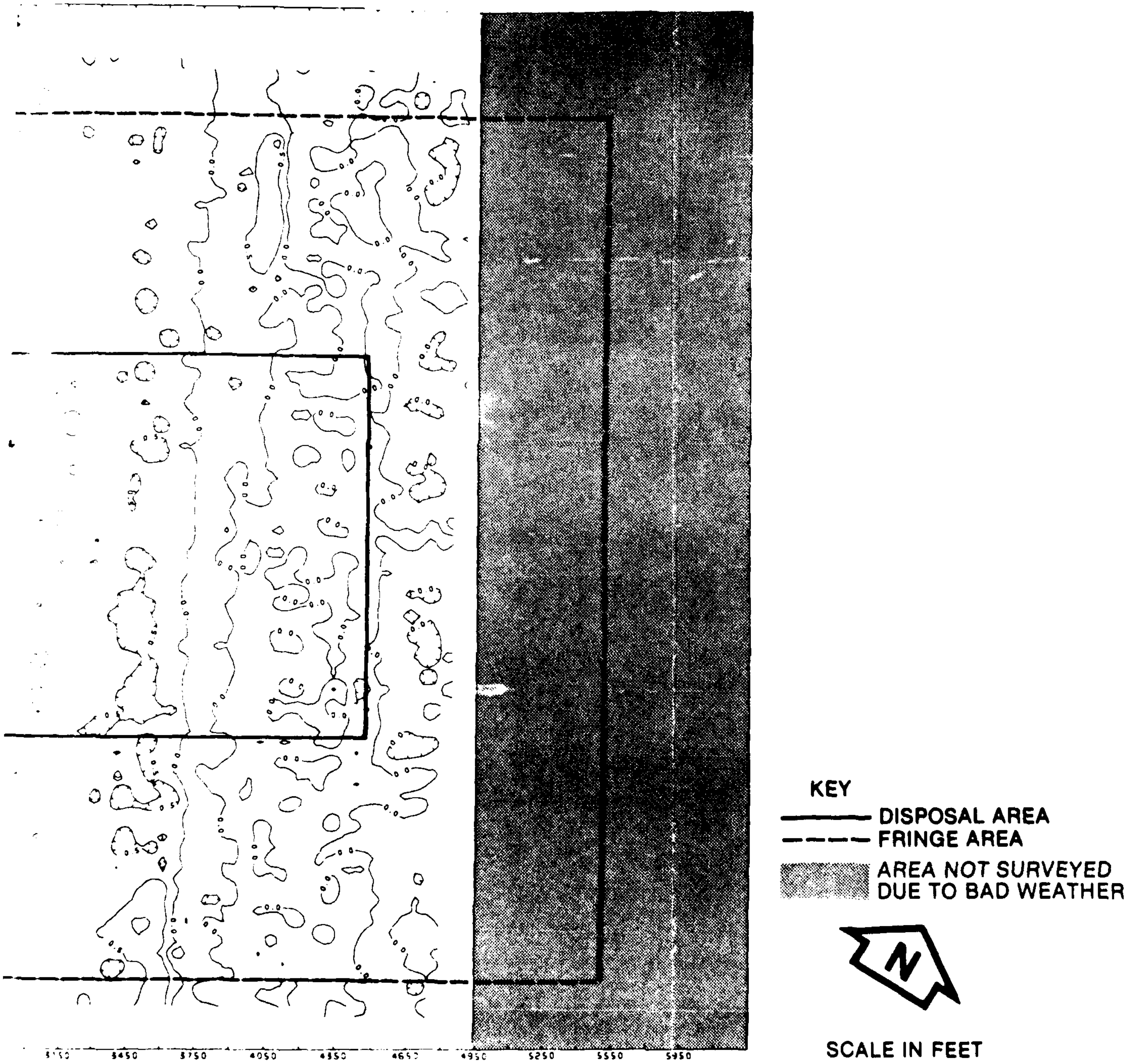


Figure 3.1-3
DIFFERENCE BETWEEN PREDISPOSAL AND 2-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND
SOURCE: ESE, 1987.



ɔF SEDIMENT DEPOSITION.

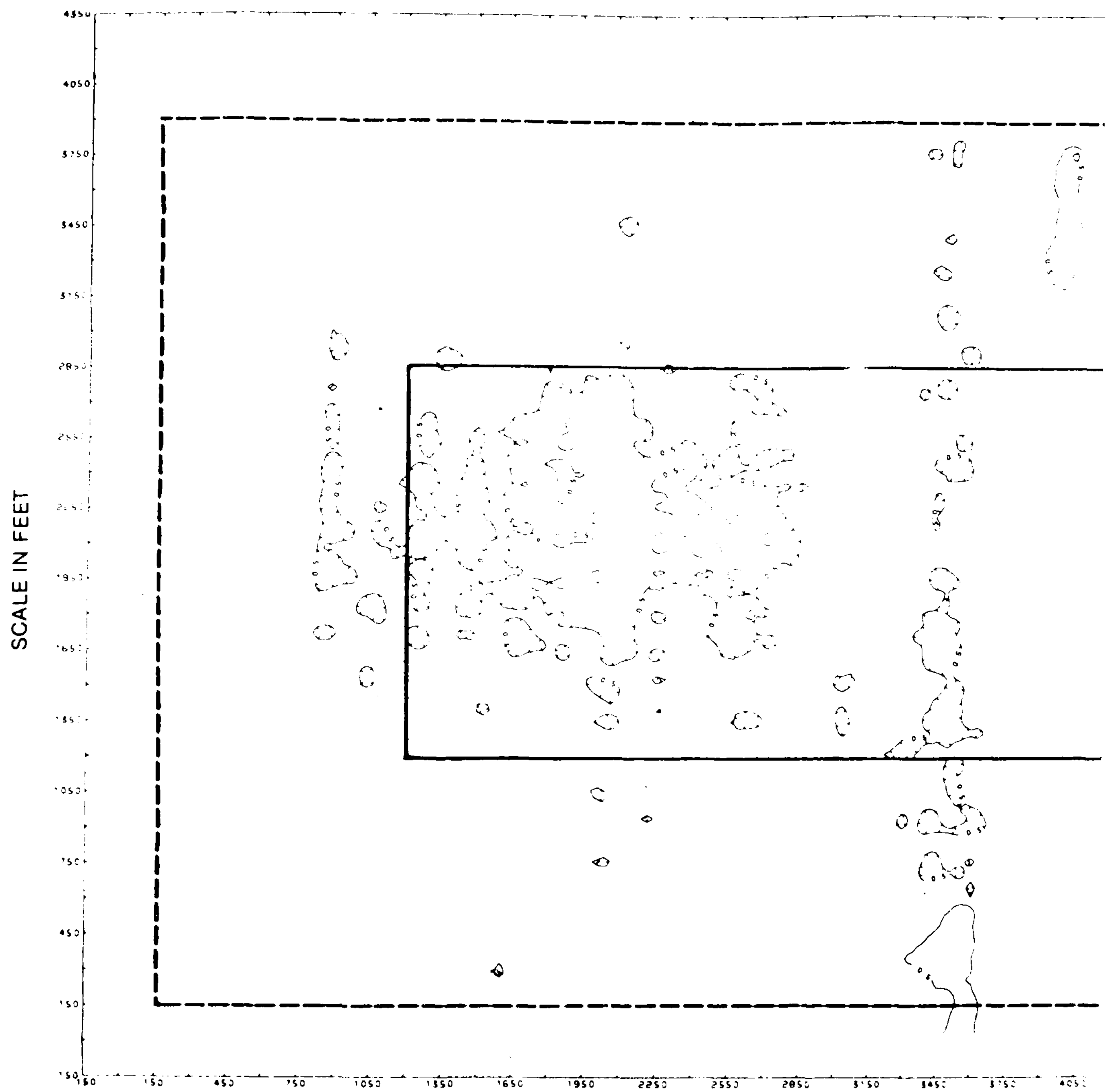
experienced strong northwesterly winds which pushed much of the water out of the Sound. Very low tides were experienced during this period.

This bathymetric chart has been modified in Figure 3.1-4 to show only those changes in depth of 0.5 ft and greater, which was the target sediment rise for the thin-layer disposal methodology.

The inherent variability in the bathymetric surveys induced by the accuracy of the instrumentation (see Section 2.1.1), as well as the effects of wave action on the survey vessel, was approximately ±0.3 ft. The bathymetric chart showing the difference between the predisposal and first post-disposal surveys presented in Figure 3.1-3 contained numerous contour lines representing changes in water depth of less than 0.5 ft, many of which are within the range of variability of the overall survey technique. The 0.0-ft contour lines were removed in Figure 3.1-4 to clearly show the actual area of sediment deposition of 0.5 ft and greater due to the thin-layer dredged material disposal operations.

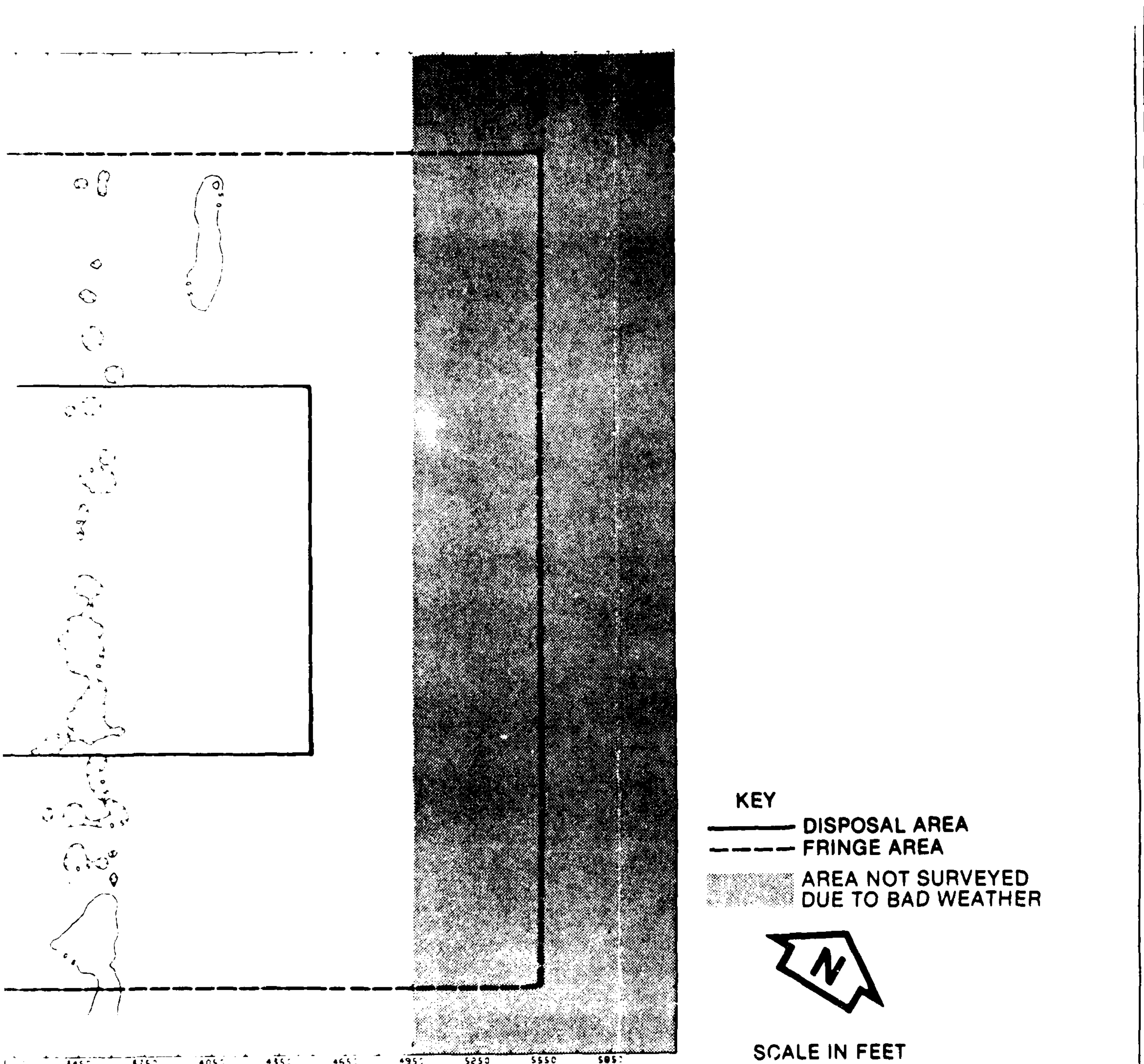
The area of sediment deposition, exceeding 0.5 ft in depth, was located primarily in the western half of the disposal area as shown in Figures 3.1-3 and 3.1-4. The maximum sediment rise in the study area was less than 1 ft in depth in all areas. From the results of the predisposal and 2-week post-disposal bathymetric surveys an estimated volume of 80,900 cubic yards (yd^3) of sediment was deposited in the study area at a depth of 0.5 ft or greater. The volume of material removed from the dredged site was estimated at 61,385 yards which would give a bulking factor of 1.3. A total of 69,800 yd^3 (86 percent of total) of the sediment deposited was located within the disposal area, with an additional 11,100 yd^3 (14 percent of total) located within the fringe area. The total areal extent of the 0.5-ft contour line within the overall study area was 514,000 square yards (yd^2), with 436,000 yd^2 (85 percent) within the disposal area and 78,000 yd^2 (15 percent) within the fringe area.

A third bathymetric survey was conducted 6 weeks after dredged material disposal operations had been completed, to evaluate the effects of



NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SEDIMENT DEPOSITION.
CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-4
DIFFERENCE OF 0.5 FT OR GREATER BETWEEN PREDISPOSAL AND 2-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND
SOURCE: ESE, 1987.



EDIMENT DEPOSITION.

dispersion, compaction and sediment drift. A bathymetric chart showing the topographic contours present during the 6-week post-disposal survey is presented in Figure 3.1-5. Variability in water depth measurements was noted to have increased during the 6-week post-disposal survey due to high winds and rough seas. This occurred in spite of the use of a larger vessel (47 ft versus the usual 24 foot vessel) and resulted in an increased variability between adjacent data points that was as high as 1 ft. during this period. This increased variability was due to vessel movement from wave action and increased the sampling error for data collected during that period.

Even though variability in depth measurements was elevated during the third survey, evidence of a sediment mound within the disposal area can be seen in Figure 3.1-5. The difference between the 6-week post-disposal and the predisposal bathymetric surveys is shown in Figure 3.1-6. An enhanced bathymetric chart showing changes in sediment depth of 0.5 ft or greater is presented in Figure 3.1-7. Results of the 6-week post-disposal survey show the remaining sediment mound within the study area (0.5 ft or greater) to have a total volume of 38,100 yd^3. A total of 30,400 yd^3 were located within the disposal area, along with 7,700 yd^3 within the fringe areas. The sediment mound identified during the 6-week post-disposal survey covered a total area of 229,000 yd^2, of which 183,000 yd^2 were located with the disposal area and 46,000 yd^2 were located within the fringe areas. The area and volume of the sediment mound (0.5 ft or greater) identified during the 6-week post-disposal survey showed a net decrease of 285,000 yd^2 (55 percent of total) and 50,500 yd^3 (62 percent of total) during the first 6 weeks following the completion of dredge disposal operations. This decrease was presumably due to sediment migration and dispersion caused by turbulence and wave action.

A bathymetric chart showing the change in topography in the study area between the 6-week and 2-week post-disposal surveys is presented in Figure 3.1-8. This comparison was made as to observe movement of materials subsequent to the disposal operation. Since most of the contour lines in Figure 3.1-8 represent a change in topography of less than 0.5 ft, a second

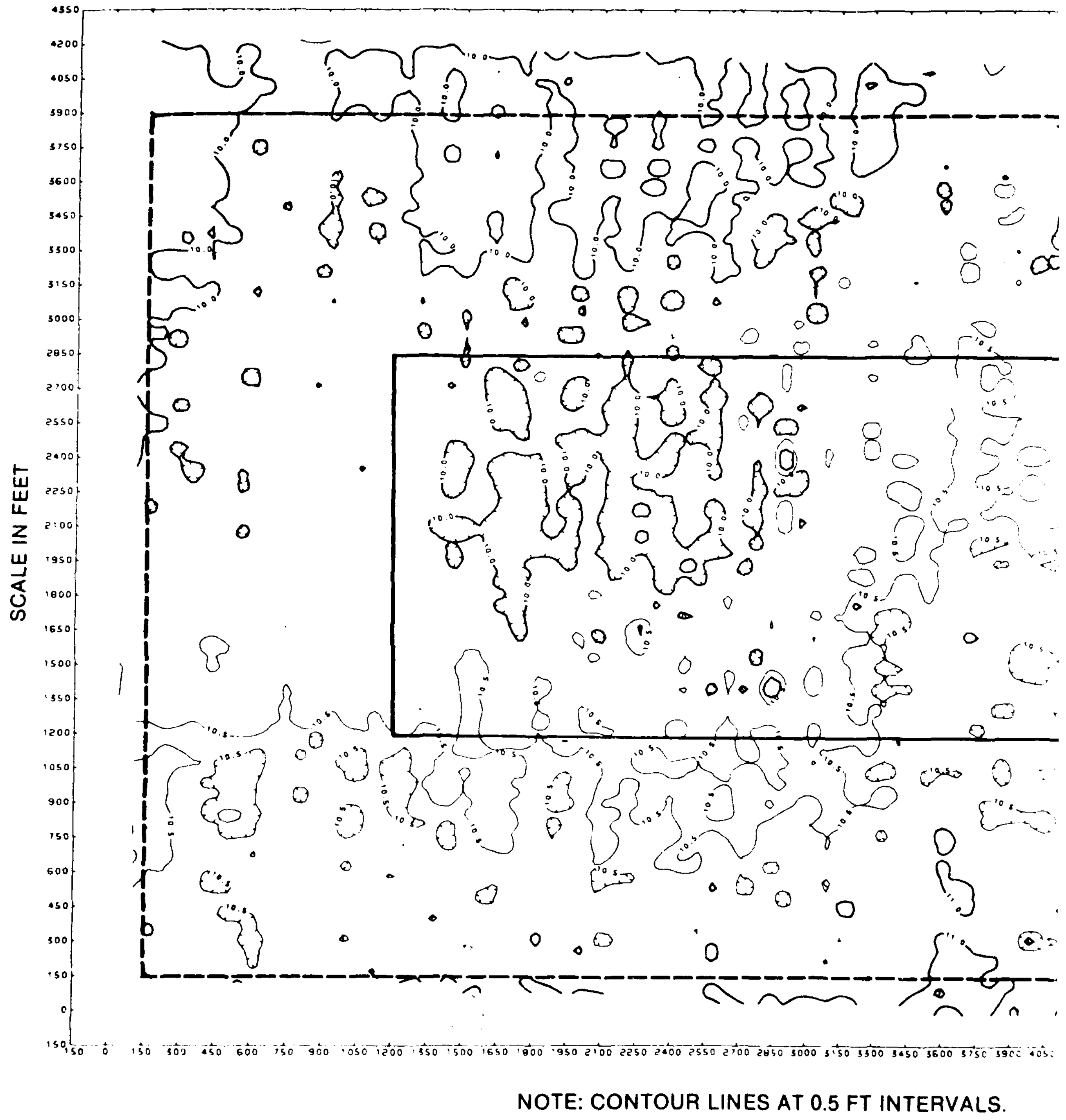
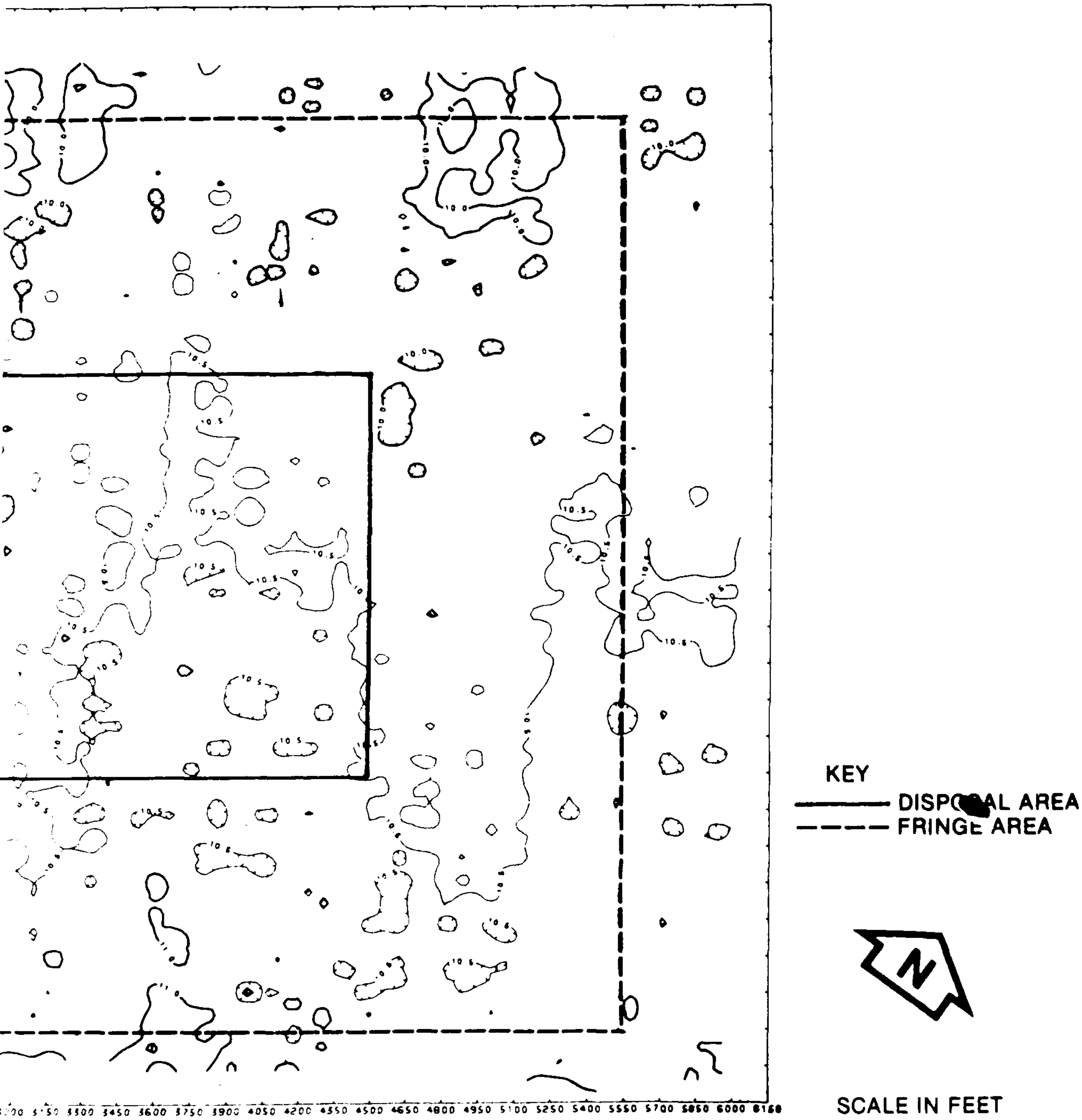
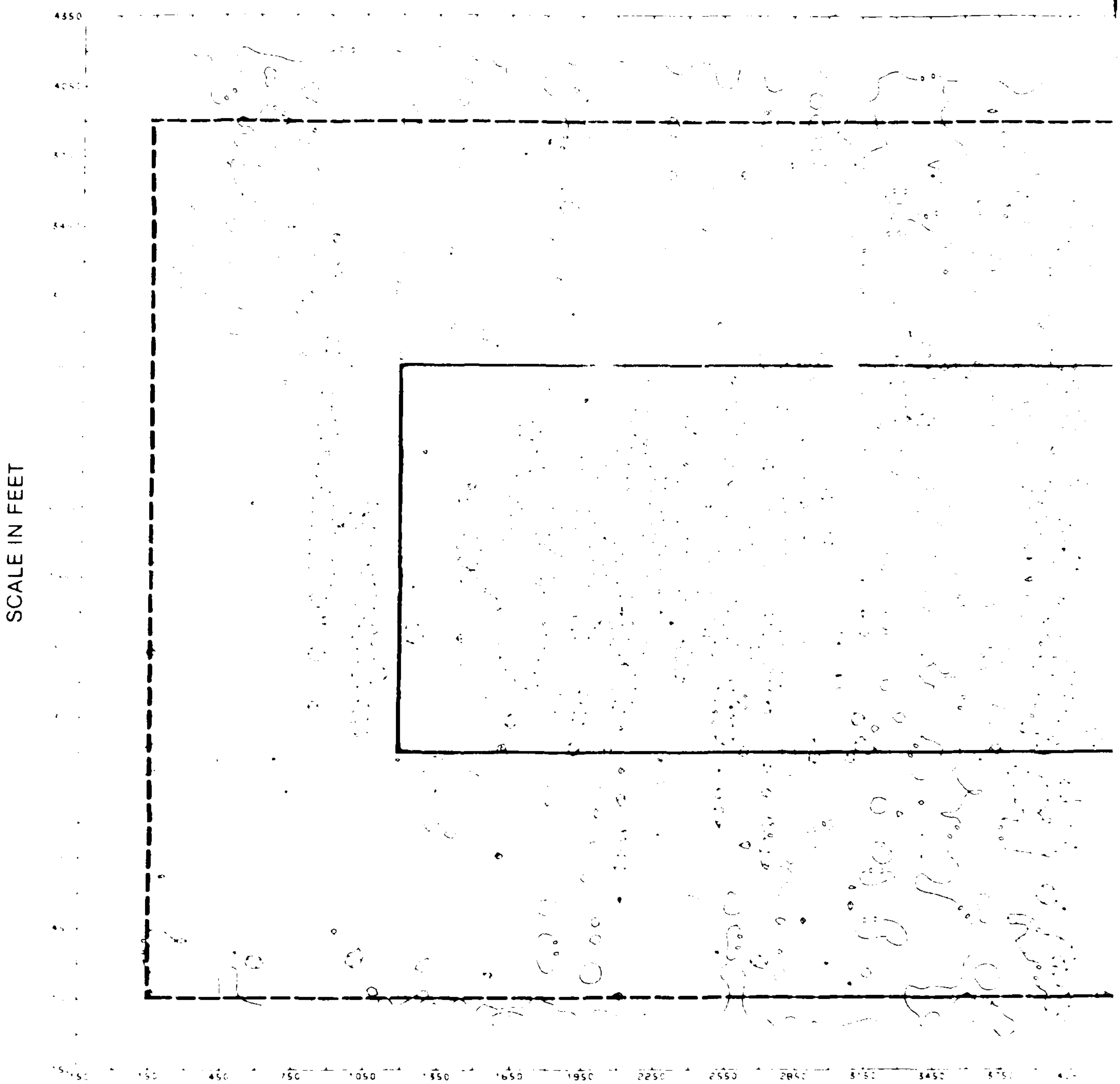


Figure 3.1-5
SIX-WEEK POST-DISPOSAL BATHYMETRIC SURVEY, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



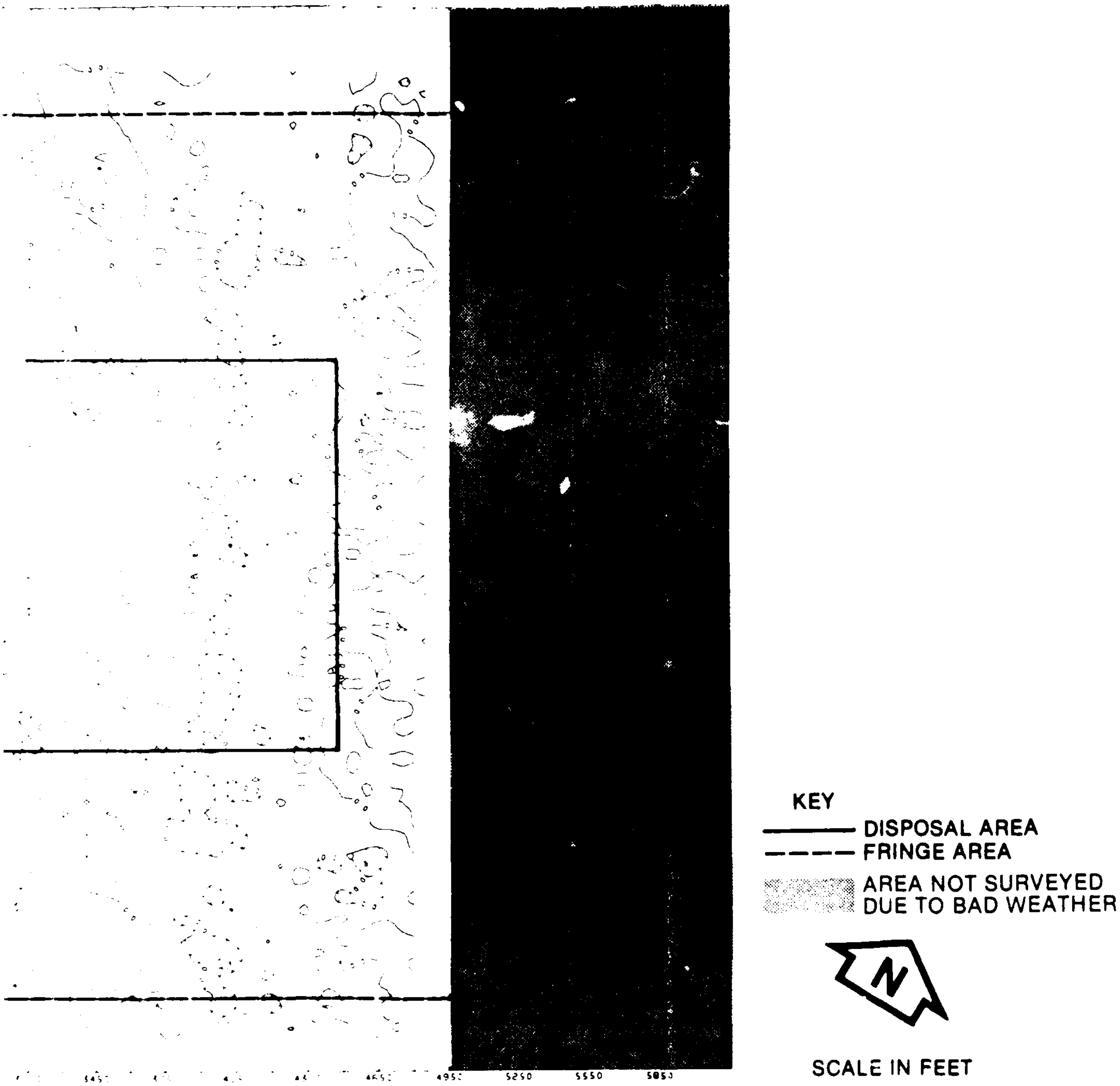
T 0.5 FT INTERVALS.



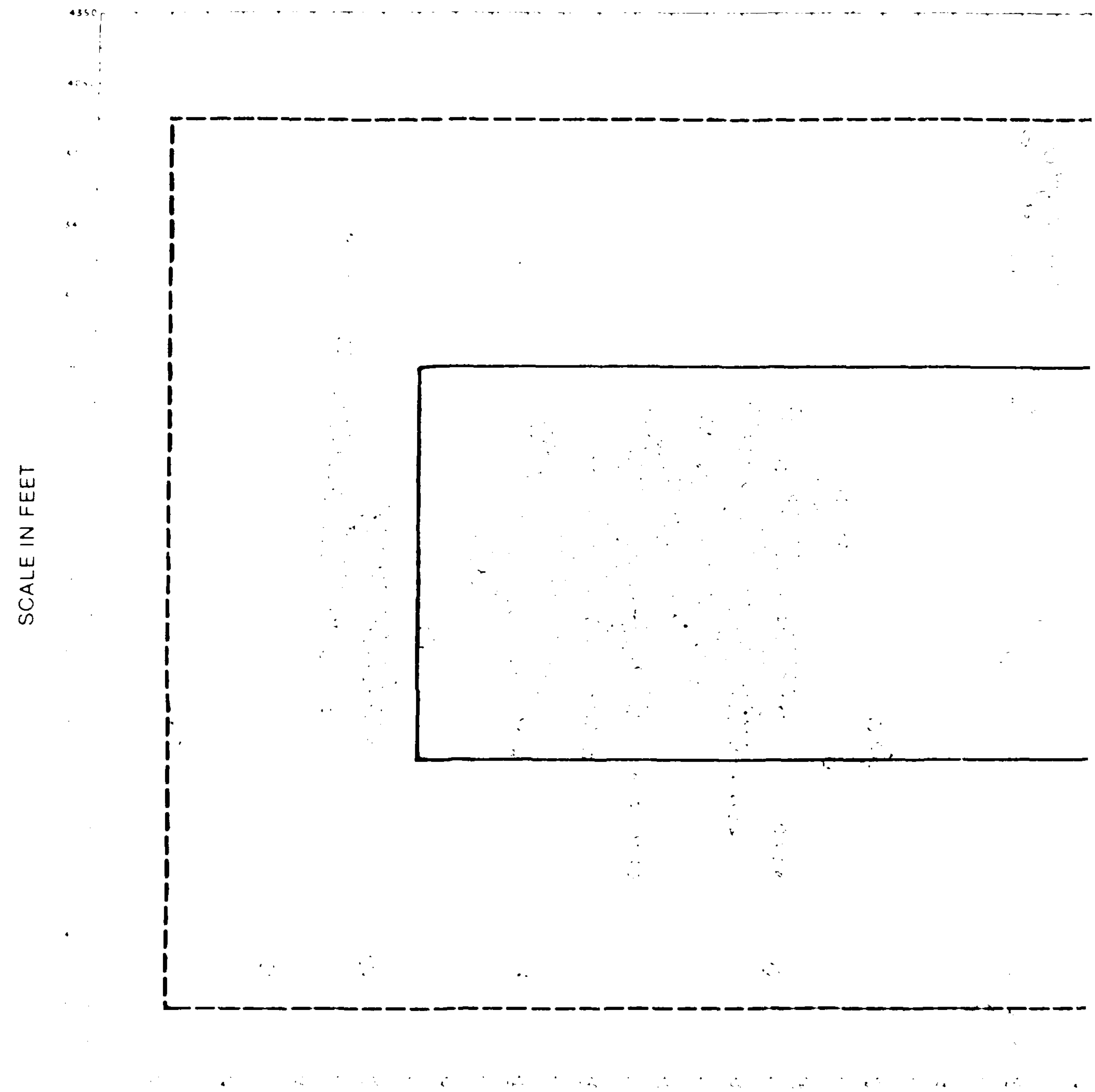
NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SEDIMENT DEPOSITION
CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-6
DIFFERENCE BETWEEN PREDISPOSAL AND 6-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



F SEDIMENT DEPOSITION.

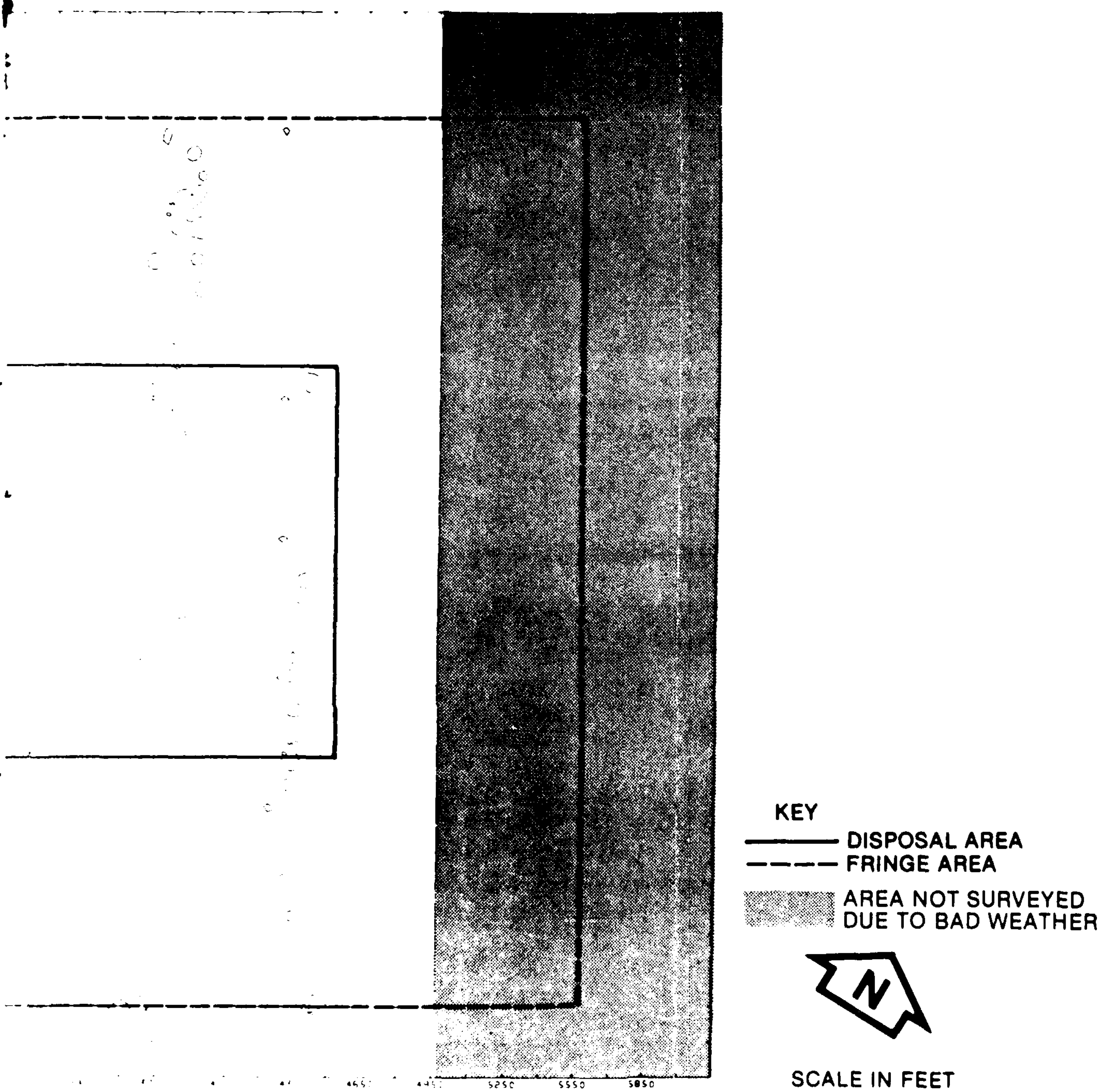


NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SEDIMENT DEPOSIT

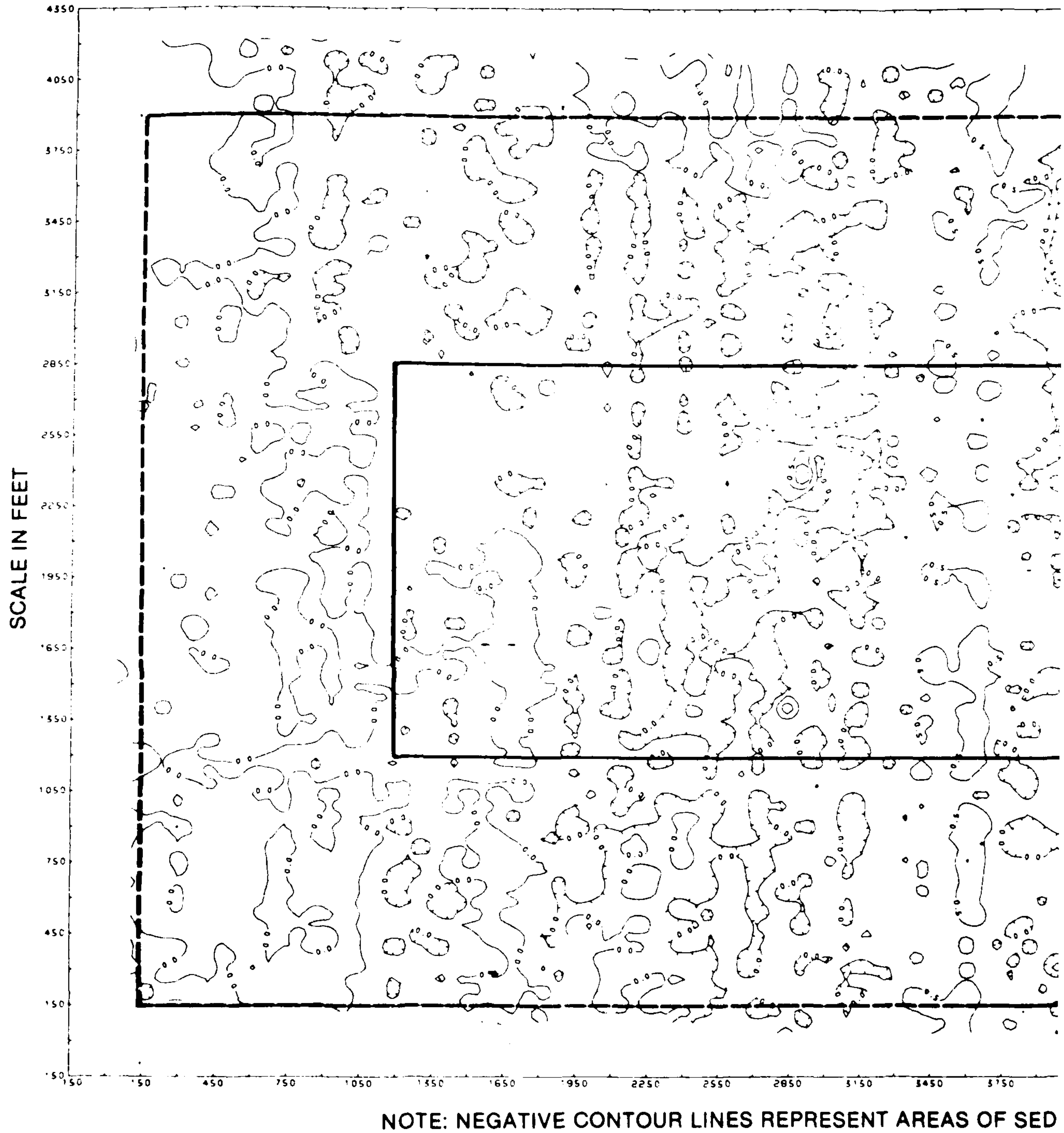
CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-7
DIFFERENCE OF 0.5 FT OR GREATER BETWEEN PREDISPOSAL AND 6-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



EDIMENT DEPOSITION.

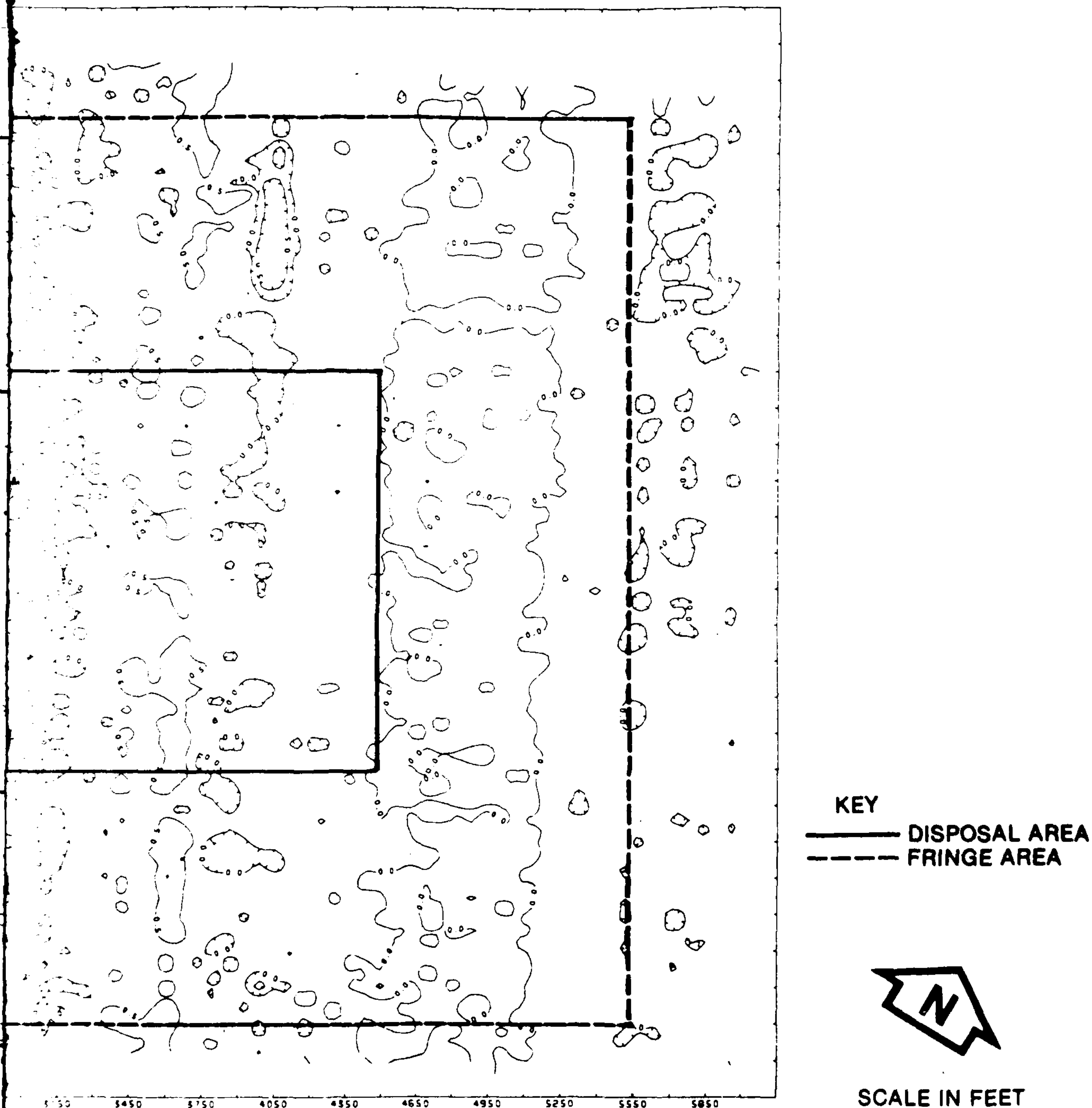


NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SED

CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-8
DIFFERENCE BETWEEN 2-WEEK POST-DISPOSAL AND 6-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



RESENT AREAS OF SEDIMENT DEPOSITION.
T RVALS.

chart showing only the contour lines of 0.5 ft or greater is presented in Figure 3.1-9. While the majority of contour lines in Figure 3.1-8 represent a change in depth of less than 0.5 ft, a decrease in sediment depth between the 6-week and 2-week post-disposal surveys did occur over a small area, as shown in Figure 3.1-9. This decrease in sediment depth, due to dispersion of dredged material, covered an area of 74,000 yd^2 with an overall volume of 11,000 yd^3.

A final bathymetric survey (Figure 3.1-10) was conducted 20 weeks after the completion of all dredged material disposal operations. The distinct area of sediment deposition evident in the disposal area during the 2-week and 6-week post-disposal surveys was not found during the 20-week post-disposal survey indicating movement or compaction of the disposed materials.

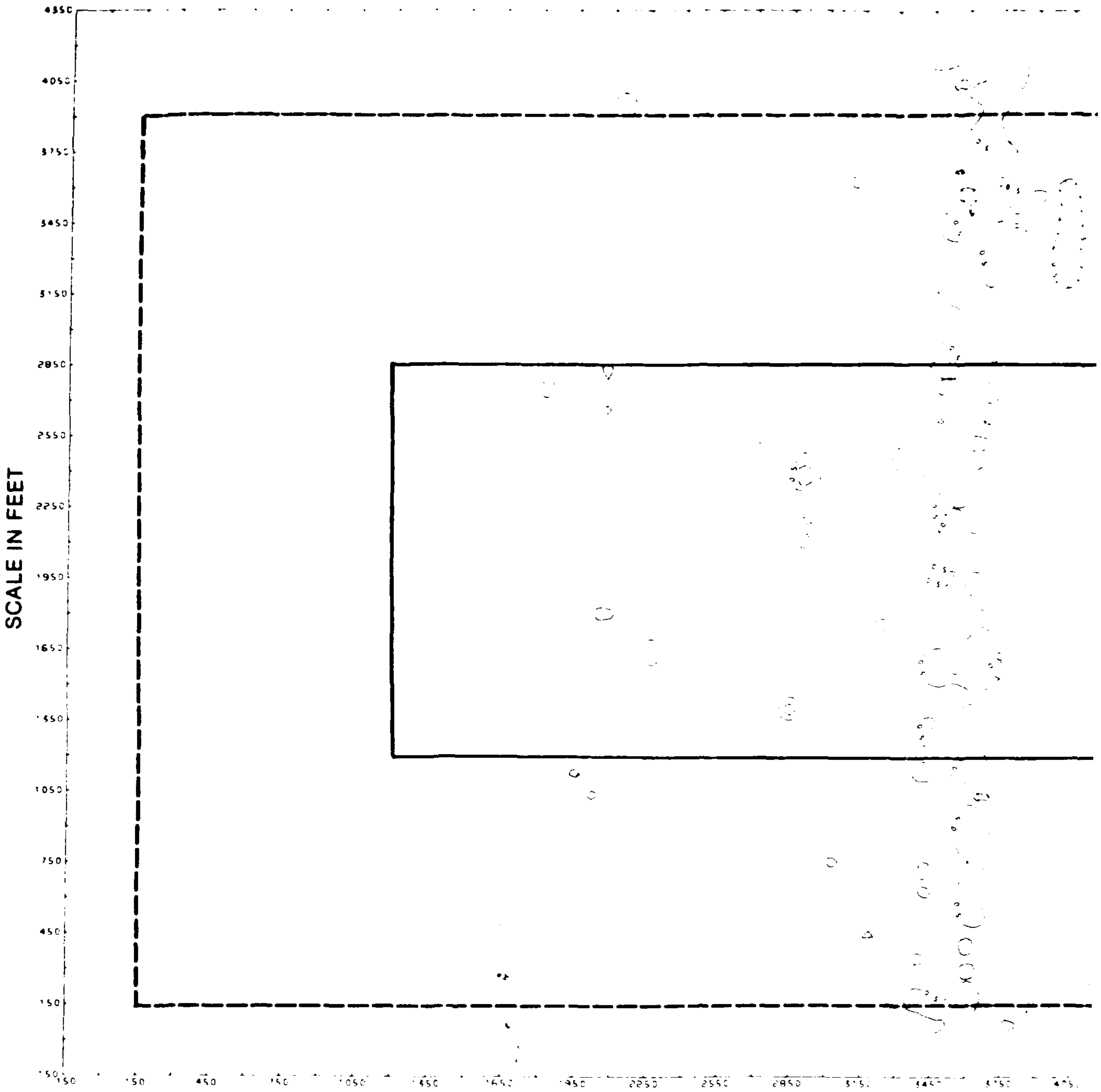
The difference between the predisposal and the 20-week post-disposal surveys is presented in Figures 3.1-11 and 3.1-12.

The total area having a rise in sediment depth of 0.5 ft or greater (26,000 yd^2) was found to be greatly reduced during the 20-week post-disposal survey. This area represented a total volume of 4,000 yd^3. As can be seen from Figure 3.1-12, the difference in the topography of the majority of the study area between the predisposal and 20-week post-disposal surveys was less than 0.5 ft.

The difference between the 20-week and 6-week post-disposal bathymetric surveys is presented in Figures 3.1-13 and 3.1-14. Very little difference in topography was evident between the two surveys, with most changes in depth less than 0.5 ft. This indicates that most movement of sediment, subsequent to the disposal operation, occurred within six weeks following the original deposition.

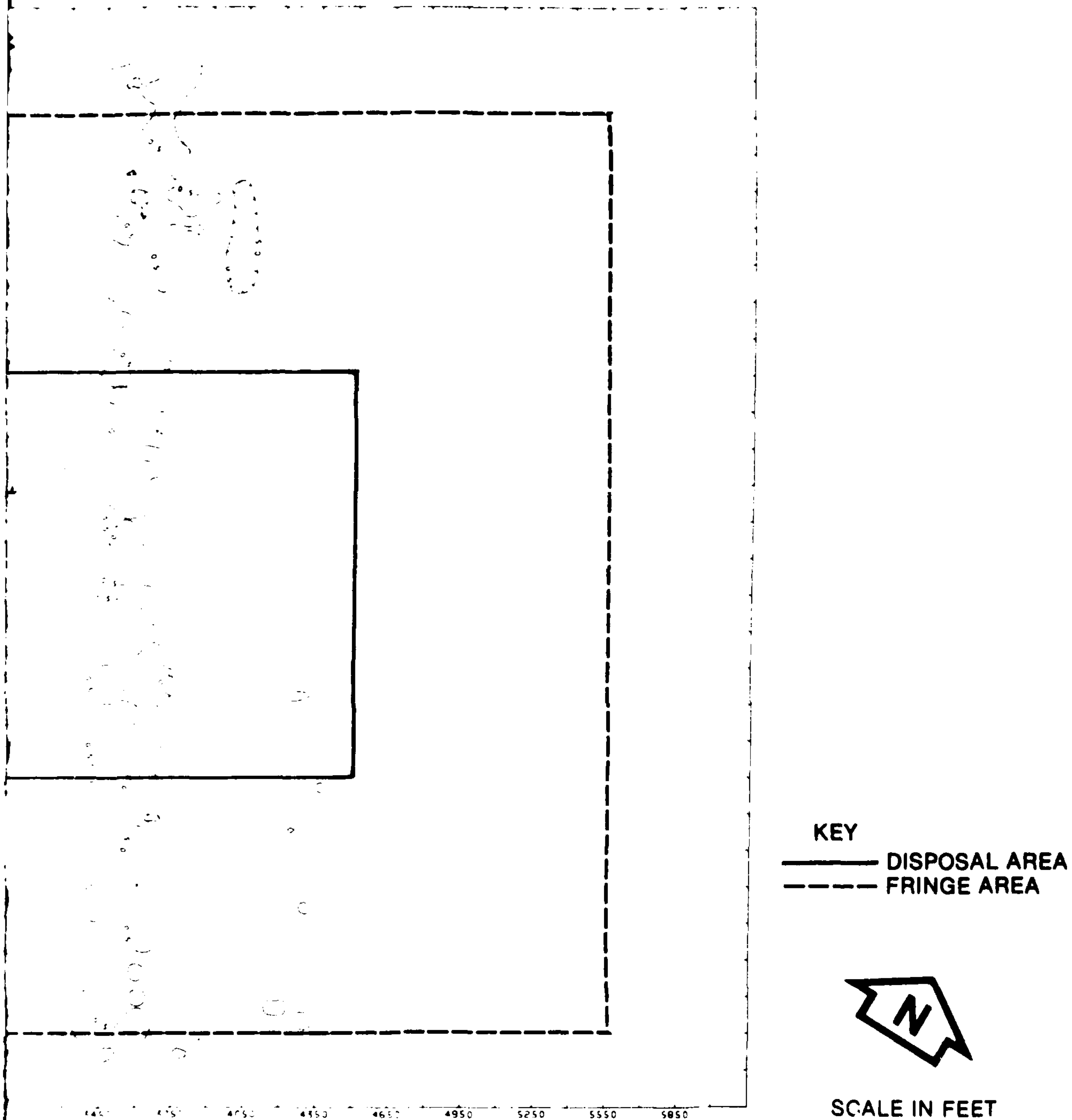
3.1.3 Water Quality

Water-quality studies were carried out concurrently with the predisposal bathymetric survey. The predisposal water-quality survey was conducted in December 1986. Air temperatures ranged from 45 to 50 degrees Fahrenheit



NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SEDIME
CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-9
DIFFERENCE OF 0.5 FT OR GREATER BETWEEN 2-WEEK POST-DISPOSAL AND 6-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND
SOURCE: ESE, 1987.



ENT AREAS OF SEDIMENT DEPOSITION.
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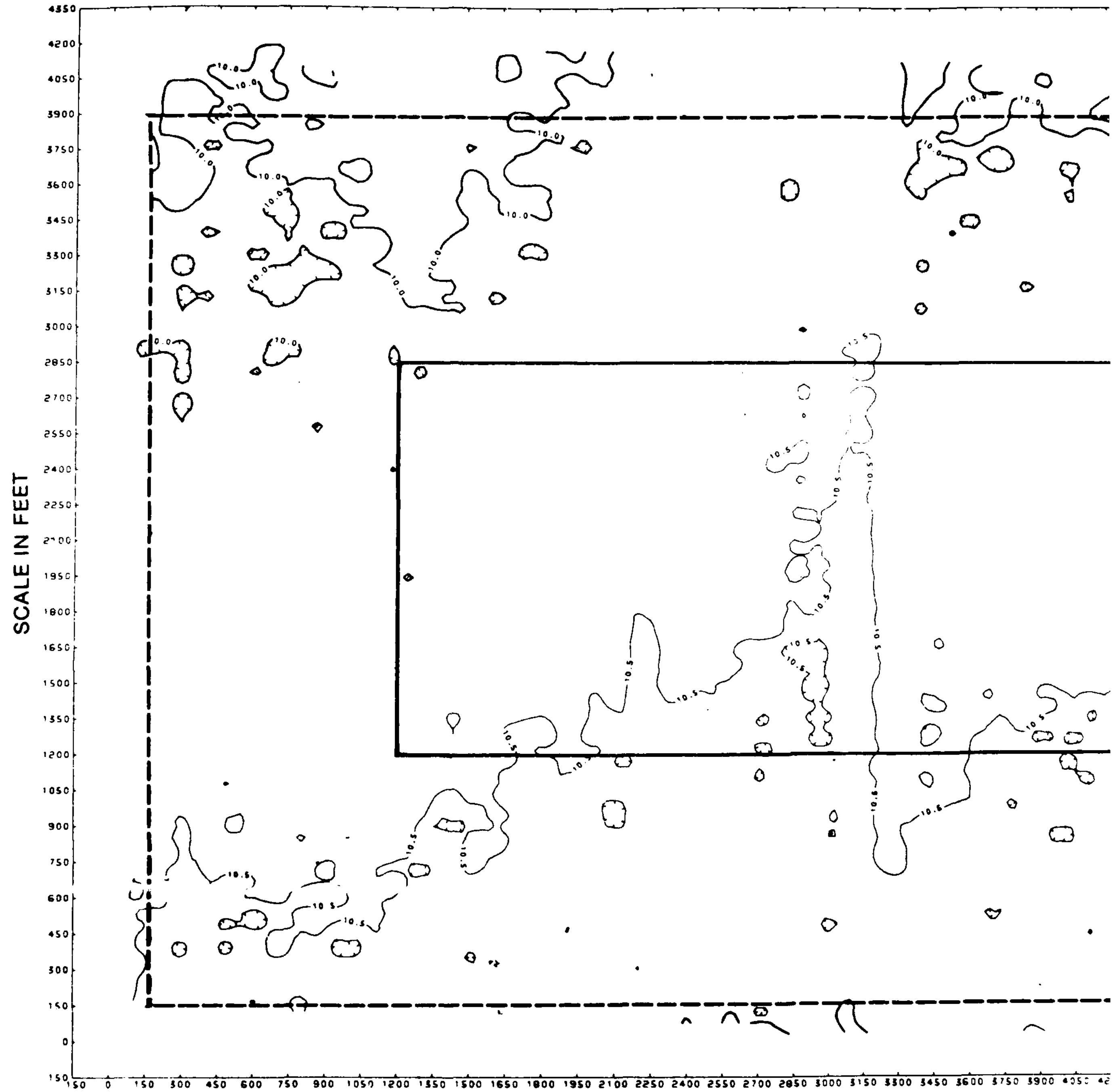
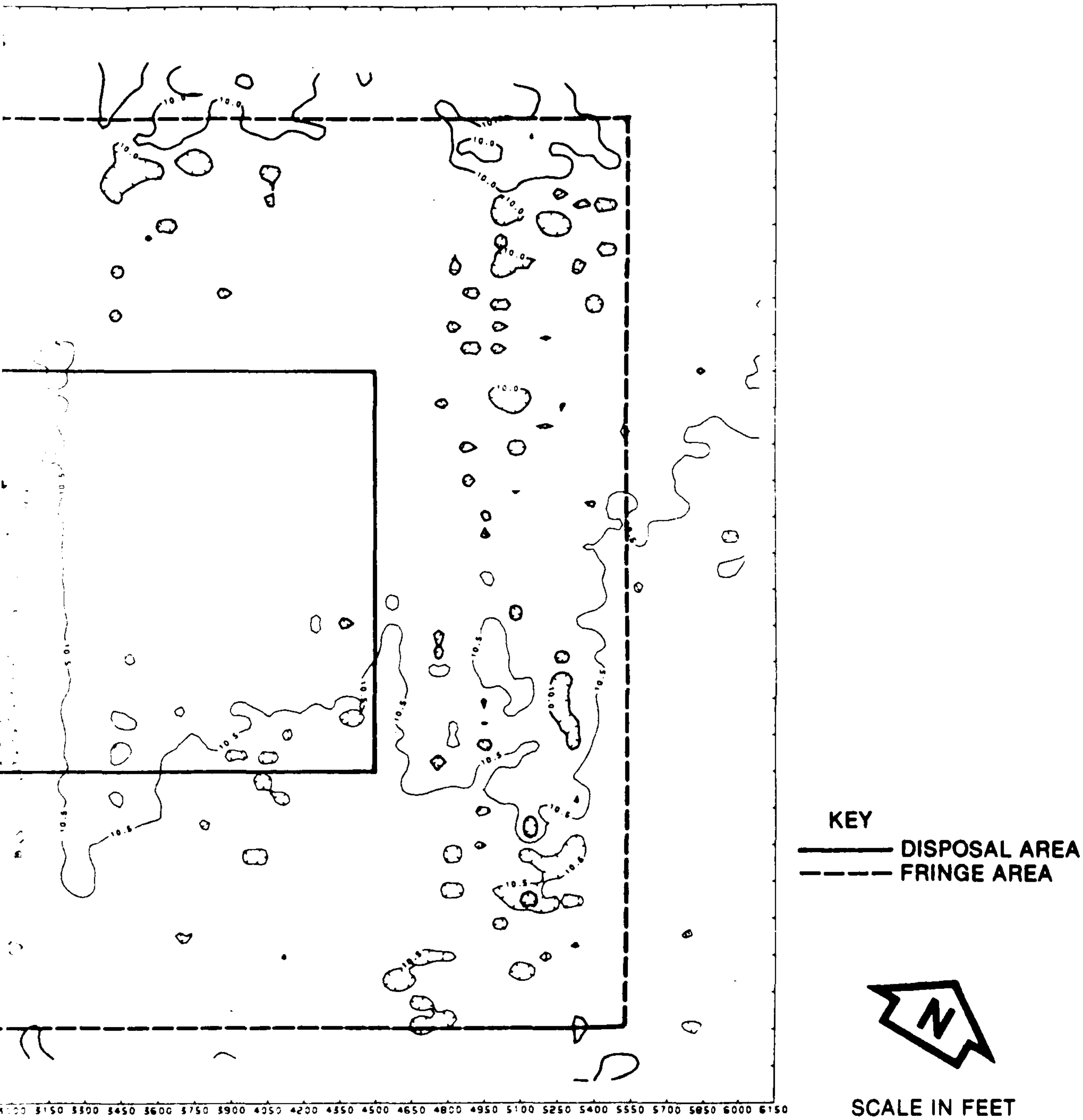


NOTE: CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-10
TWENTY-WEEK POST-DISPOSAL BATHYMETRIC SURVEY, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



T 0.5 FT INTERVALS.

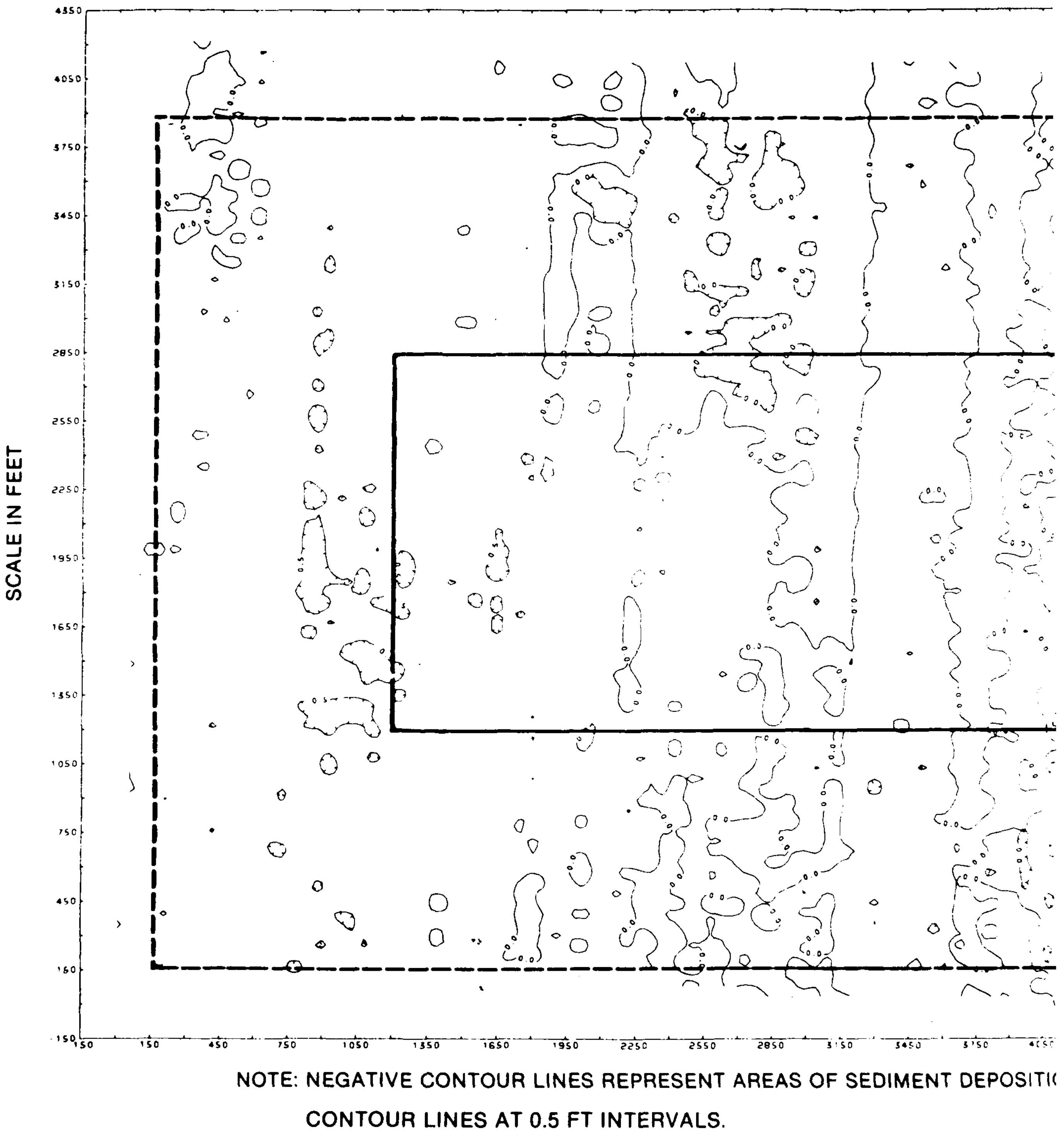
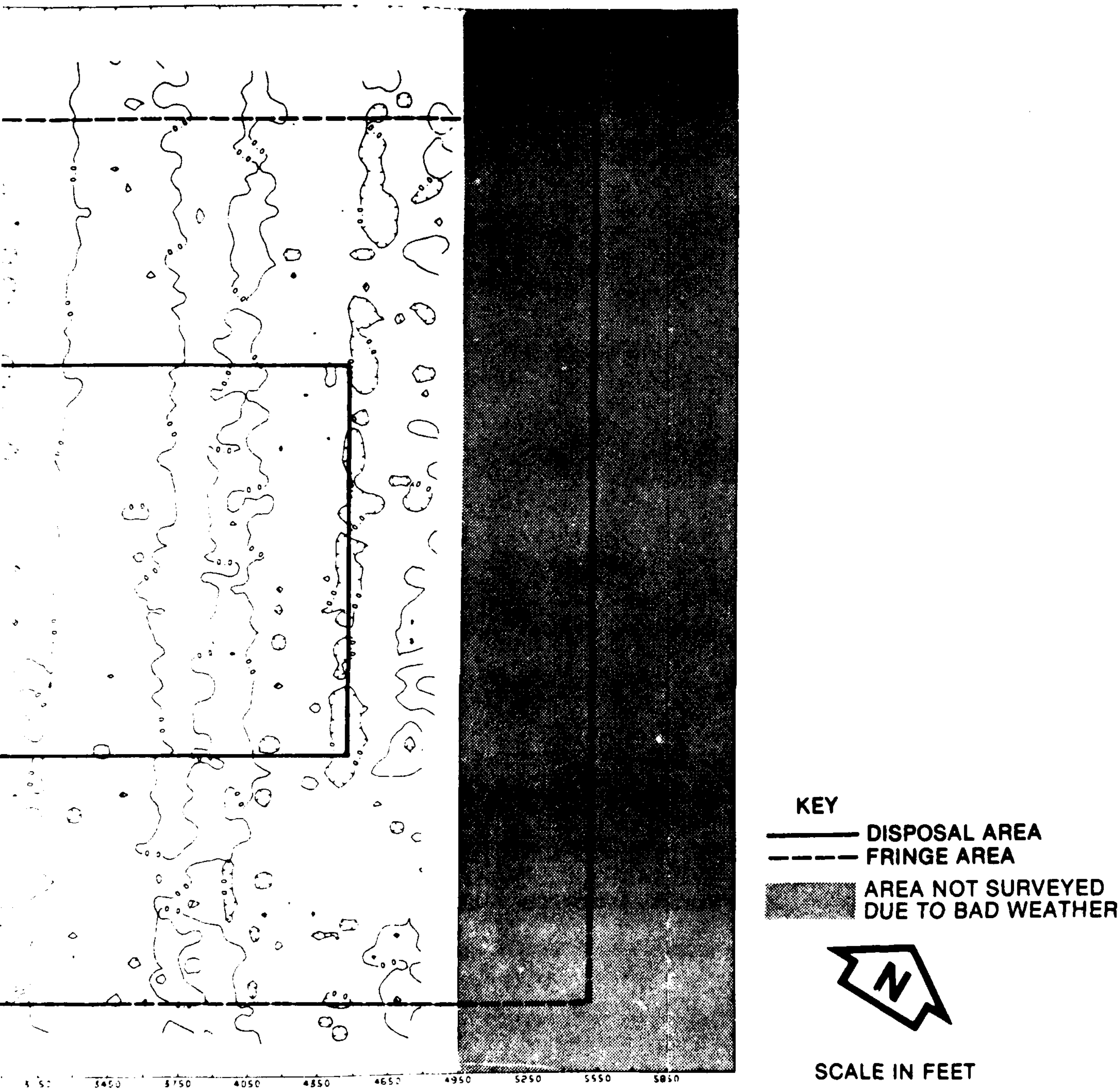
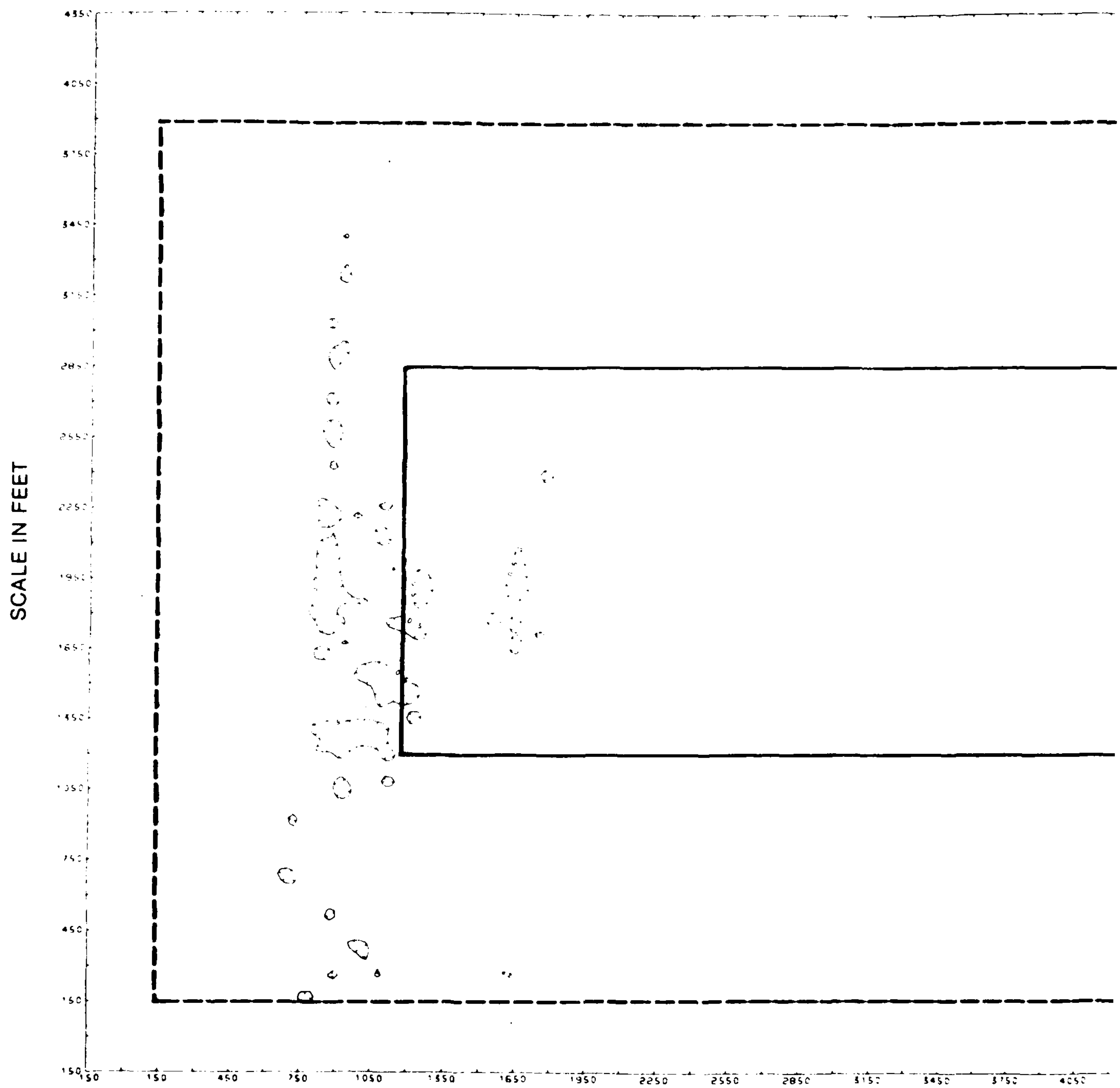


Figure 3.1-11
DIFFERENCE BETWEEN PREDISPOSAL AND 20-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND
SOURCE: ESE, 1987.



OF SEDIMENT DEPOSITION.

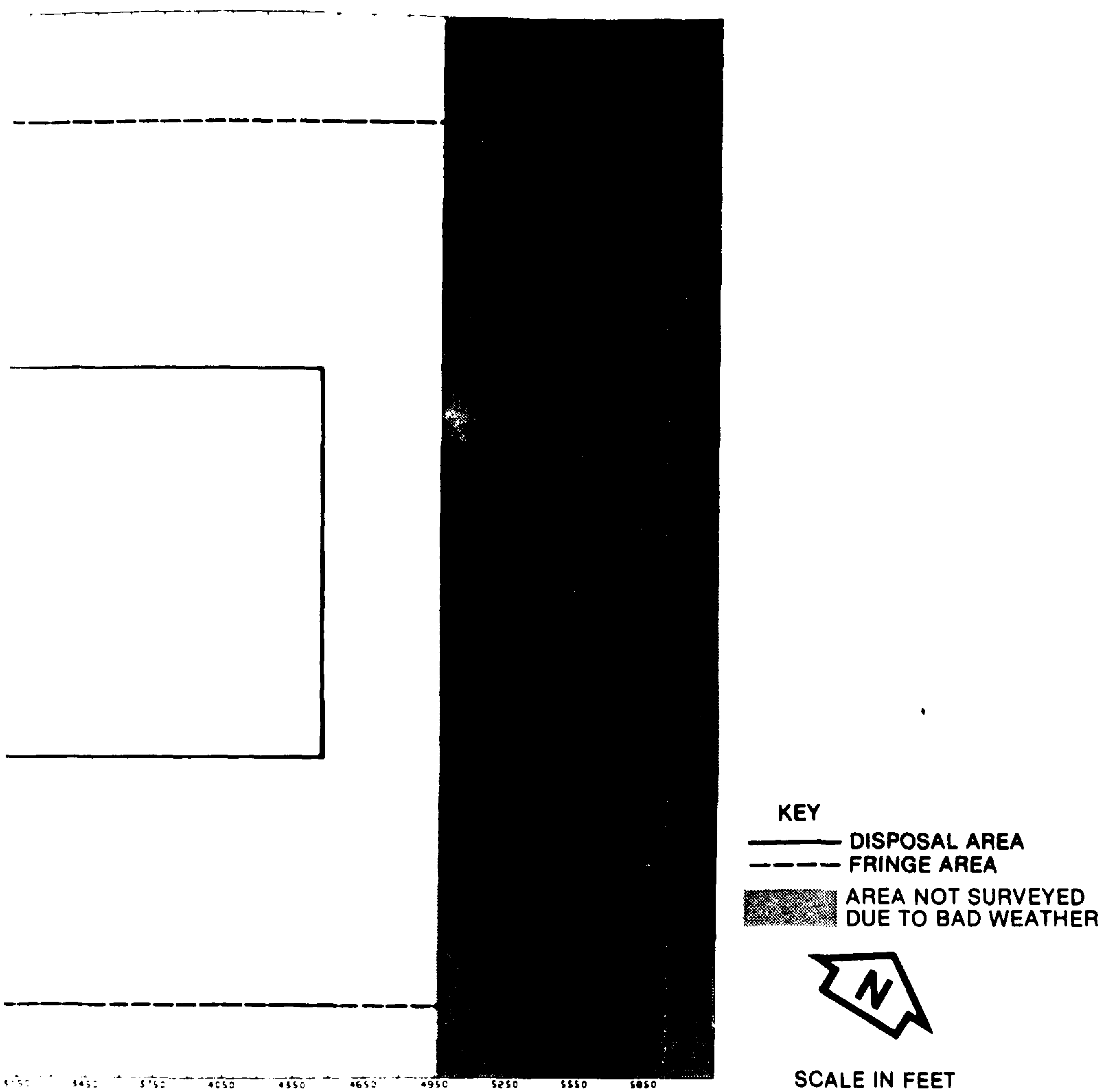


NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SEDIMENT DEPOSITION

CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-12
DIFFERENCE OF 0.5 FT OR GREATER BETWEEN PREDISPOSAL AND 20-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



F SEDIMENT DEPOSITION.

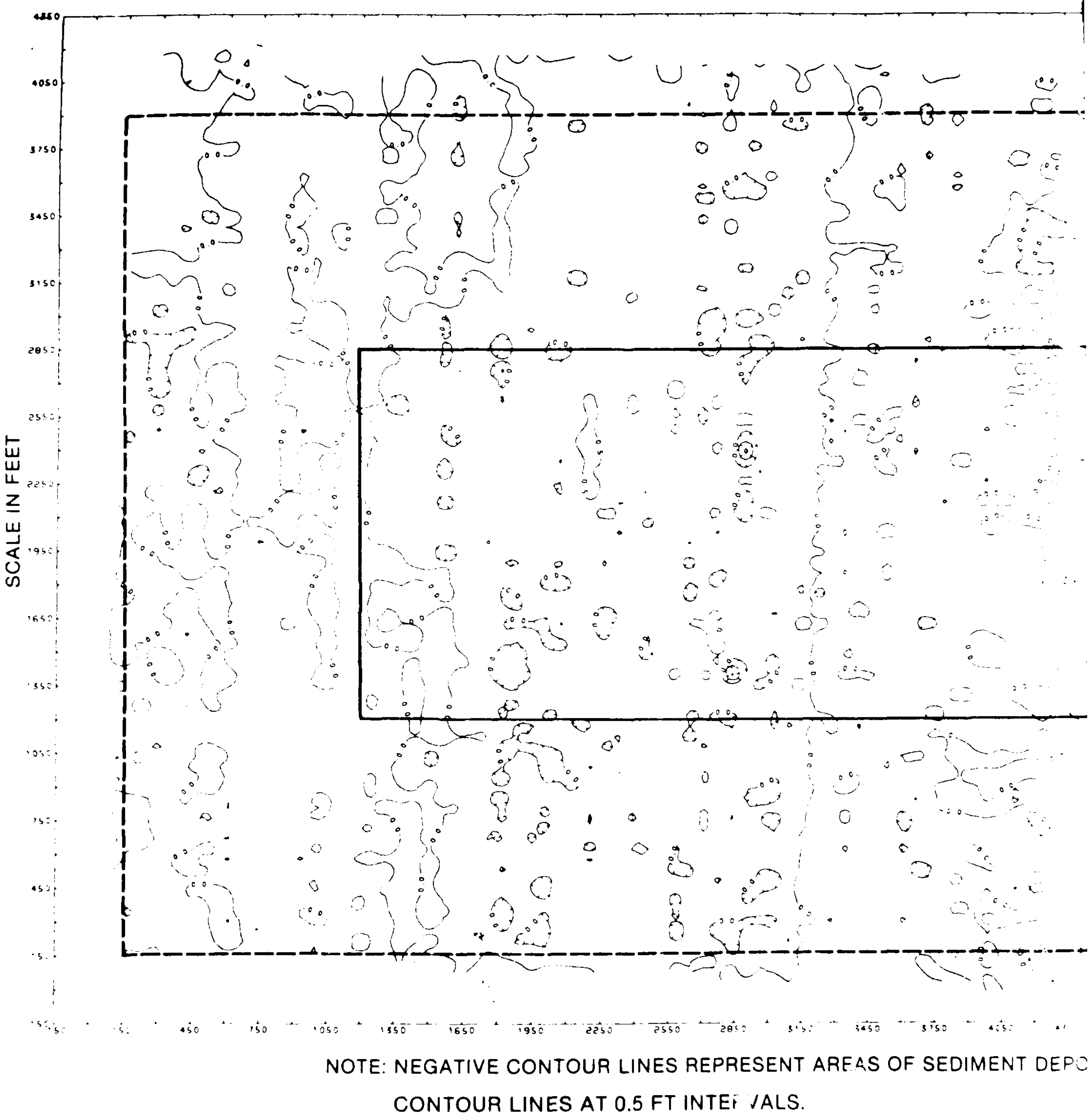
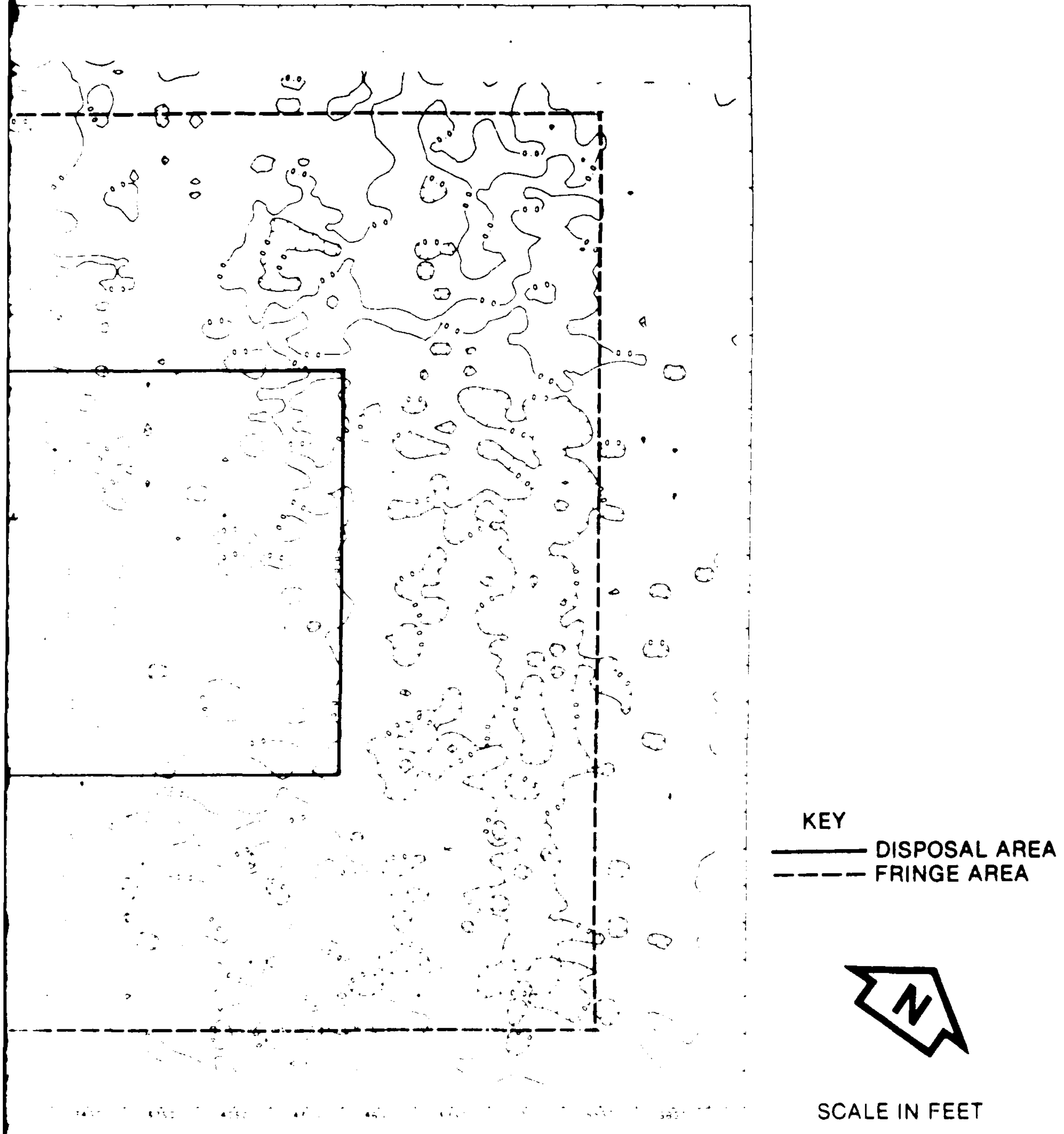


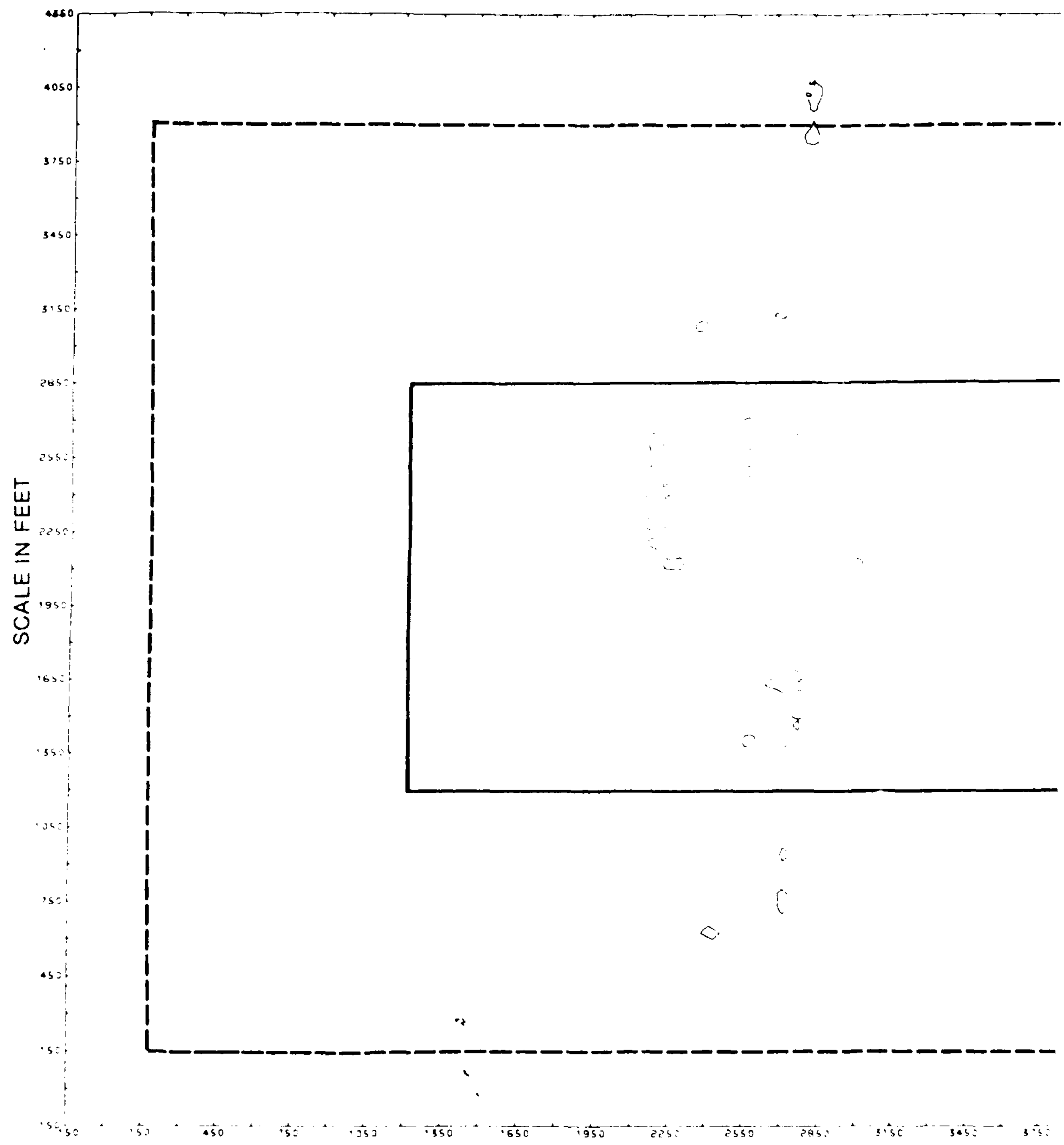
Figure 3.1-13
DIFFERENCE BETWEEN 6-WEEK AND 20-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE. ESE, 1987.



AREAS OF SEDIMENT DEPOSITION.

S.

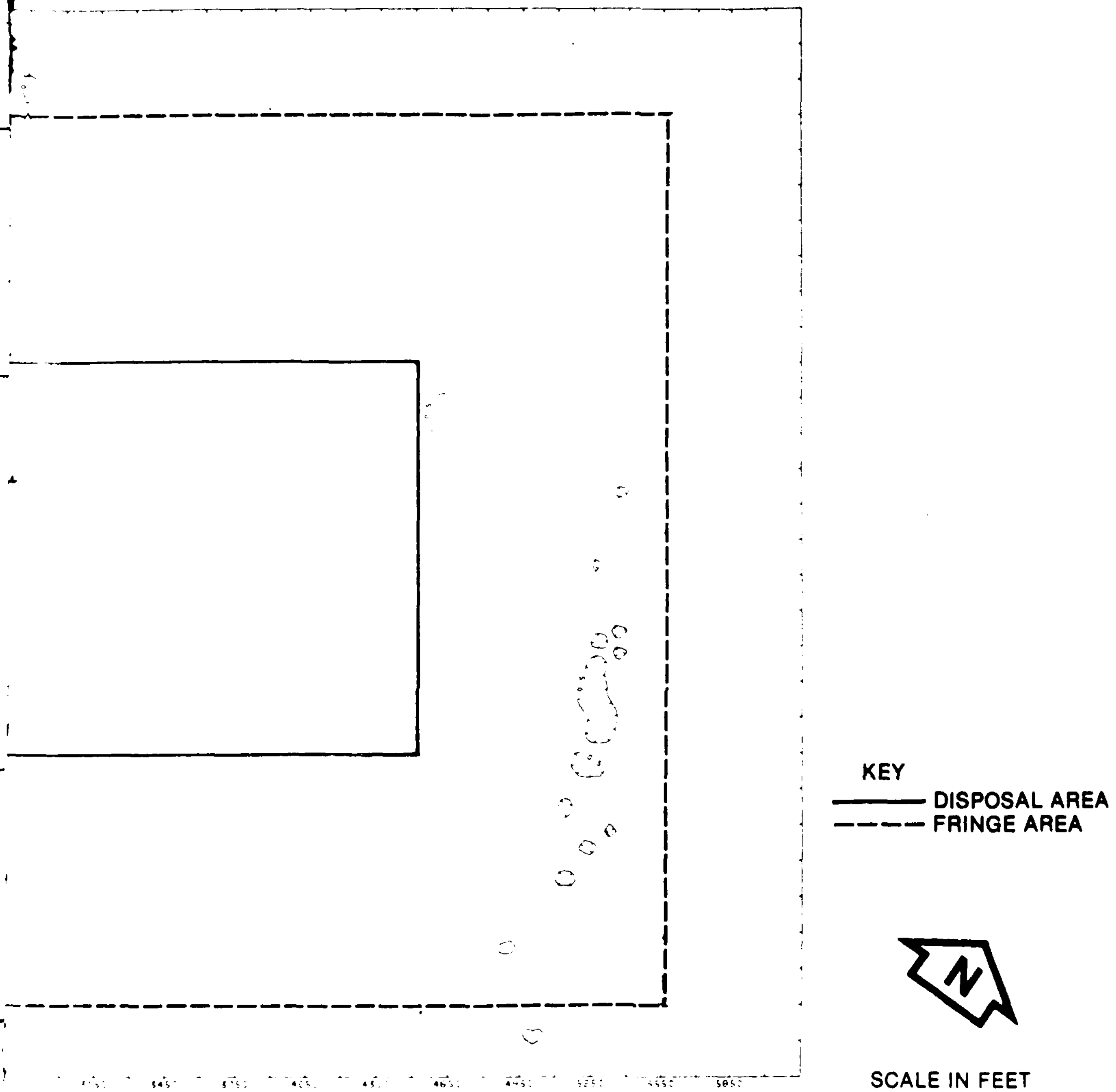


NOTE: NEGATIVE CONTOUR LINES REPRESENT AREAS OF SE

CONTOUR LINES AT 0.5 FT INTERVALS.

Figure 3.1-14
DIFFERENCE OF 0.5 FT OR GREATER BETWEEN 6-WEEK AND 20-WEEK POST-DISPOSAL BATHYMETRIC SURVEYS, GULFPORT SHIP CHANNEL DISPOSAL AREA, MISSISSIPPI SOUND

SOURCE: ESE, 1987.



NT PRESENT AREAS OF SEDIMENT DEPOSITION.
ERVALS.

(°F). Wind direction was primarily from the south at about 4 to 8 knots (Kn), and seas ranged from 2 to 4 ft. Complete analytical results for DO, salinity, temperature, and TSS are presented in Appendix A.

Dissolved Oxygen—DO values measured during the predisposal water-quality study ranged from 7.8 to 10.4 ppm, with a mean of 8.8 ppm. Mean DO concentrations at all 10 sampling sites were highly similar, with mean values at the various stations ranging from 8.7 to 8.9 ppm (see Table 3.1-1). Vertical distribution of DO concentrations at the 10 stations was highly uniform, with a range of less than 0.4 milligrams per liter (mg/L) between the surface and bottom of the water column.

Temperature—Mean water temperature during the predisposal water-quality survey was 12.6°C, with a range in individual values of 12.0 to 13.0°C. Mean water temperatures at the individual stations were all 12.6°C (see Table 3.1-1). No consistent vertical gradient in water temperature was observed during the predisposal survey.

Salinity—Mean salinity in the study area during the predisposal water-quality survey was 21.9 ppt, with a range in individual values of 21.4 to 22.5 ppt. Mean salinity values for the individual stations during the predisposal survey were highly similar, ranging from 21.7 to 22.0 ppt (see Table 3.1-1).

Current Speed and Direction—Current measurements taken during the predisposal water-quality survey were uniformly low, with a mean current speed of 0.1 Kn and a range of <0.1 to 0.3 Kn. Current direction during flood tide was predominately toward the west, whereas current direction during ebb tide was primarily toward the south.

Total Suspended Solids—The mean TSS concentration in the study area during the predisposal water-quality survey was 14 mg/L with a range in individual values of <5.0 to 74 mg/L. Mean TSS values at the individual stations ranged from 13 to 15 mg/L.

Table 3.1-1. Mean DO, Temperature, Salinity, and TSS Values from the Predisposal Water Quality Survey.

Station Number	DO (mg/L)	Temperature (°C)	Salinity (ppt)	TSS (mg/L)
1	8.9 (8.0 - 10.4)	12.6 (12.3 - 12.9)	22.0 (21.6 - 22.4)	15 (<5.0 - 35)
2	8.8 (8.0 - 9.6)	12.6 (12.1 - 12.9)	22.0 (21.6 - 22.5)	15 (<5.0 - 34)
3	8.8 (8.0 - 9.5)	12.6 (12.3 - 13.0)	22.0 (21.6 - 22.4)	15 (6.0 - 34)
4	8.8 (7.8 - 9.6)	12.6 (12.2 - 13.0)	22.0 (21.6 - 22.4)	14 (<5.0 - 43)
5	8.9 (8.2 - 10.0)	12.6 (12.0 - 13.0)	21.9 (21.5 - 22.3)	14 (<5.0 - 74)
6	8.8 (8.0 - 9.5)	12.6 (12.3 - 13.0)	21.9 (21.6 - 22.3)	14 (<5.0 - 60)
7	8.7 (8.1 - 9.4)	12.6 (12.2 - 13.0)	21.9 (21.6 - 22.3)	14 (<5.0 - 28)
8	8.8 (8.0 - 9.7)	12.6 (12.3 - 13.0)	21.9 (21.6 - 22.4)	14 (<5.0 - 31)
9	8.7 (7.9 - 9.5)	12.6 (12.3 - 12.9)	21.9 (21.6 - 22.3)	14 (<5.0 - 47)
10	8.7 (7.9 - 9.7)	12.6 (12.4 - 12.9)	21.7 (21.4 - 22.3)	13 (<5.0 - 28)

Note: Values in parentheses are minimum and maximum.

3.1.4. Sediment Analysis Analysis of the sediment samples collected during the 2-week predisposal benthic sampling program showed a relatively homogeneous sediment within the study area (Figure 3.1-15). The classification (Folk's) was a silty mud to clayey mud texture. By the 2-week post-disposal survey, a peak of smaller diameter (finer) material was deposited in the western part of the disposal area. By the 6-week post-disposal period the peak was essentially obliterated, presumably by physical and biological reworking of the sediment. The 20-week post disposal survey had a slightly lower average phi value than the other periods perhaps in part due to a seasonal change in wind and current patterns.

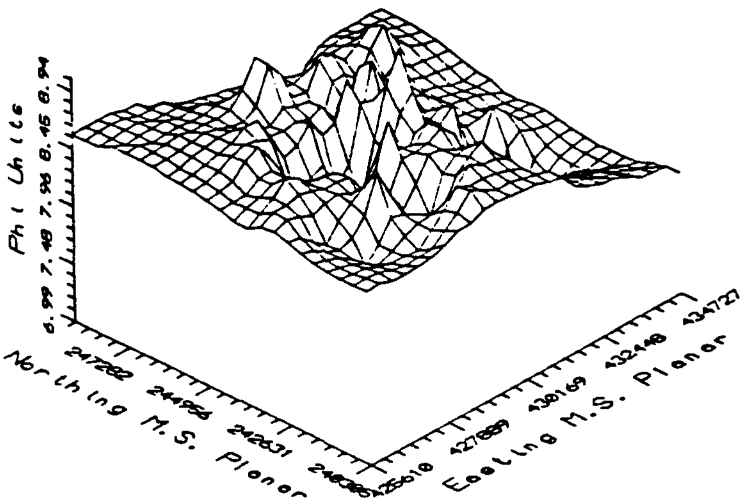
3.1.5 Vertical Sediment Profile Imagery

Results from the analysis of images obtained by vertical sediment profile imagery system are presented in Appendix D and are summarized below.

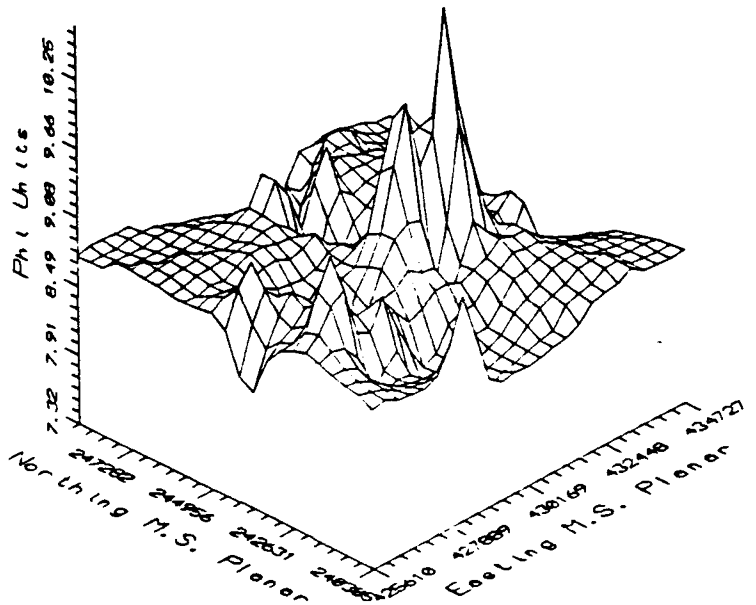
In general, sediment profile photographs for the Gulfport Harbor study were of low contrast which necessitated the utilization of color slides at the stations to improve contrast. These images had the broadest range in the red plane which were associated with the brown tones of oxidized superficial sediments and facilitated the identification of the reduced potential discontinuity (RPD) layer. Overall, the entire surface area was relatively homogeneous in appearance which is illustrated in representative photographs of the area (Plates 3.1-1 and 3.1-2). Subsurface sediments were light grey in tone. Dredged material was slightly lighter in grey tone and had a very homogeneous textural appearance making identification of the dredged materials relatively easy.

Prism penetration of the camera ranged from 5-10 cm throughout the entire study area. The variation in penetration seemed to be of a random nature indicating a relative homogeneity in terms of compaction. Based on the photography, the sediments were classified as a silty-clayey mud and were very uniform over the entire study area. The grain size of the dredged material was the same as the background material and did not add any heterogeneity to the area.

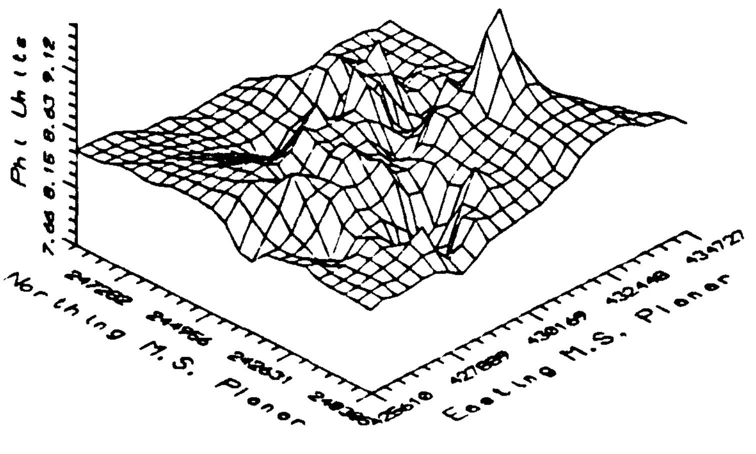
2-Week Pre-Disposal

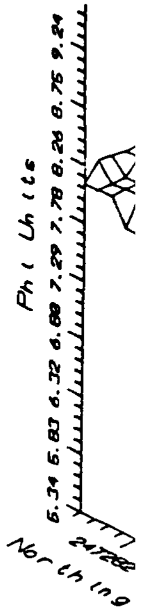


2-Week Post-Disposal



6-Week Post-Disposal





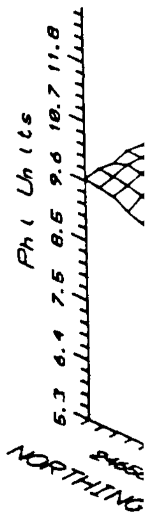
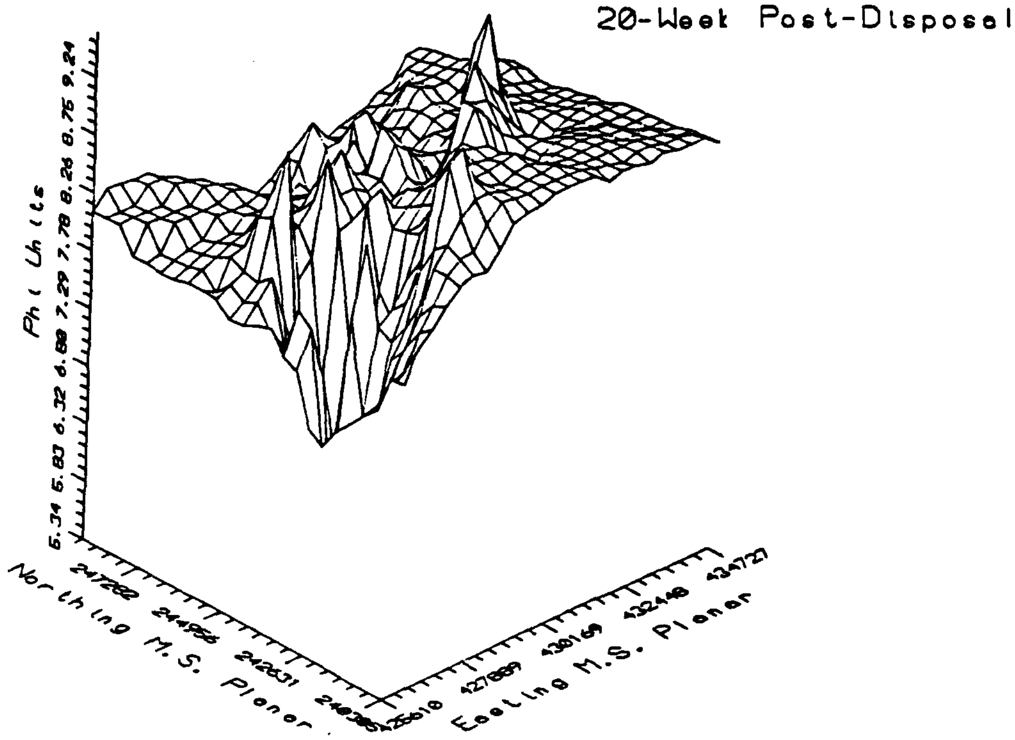


FIGURE 3.1-15.
COMPOSITION AT
STUDY AREA.



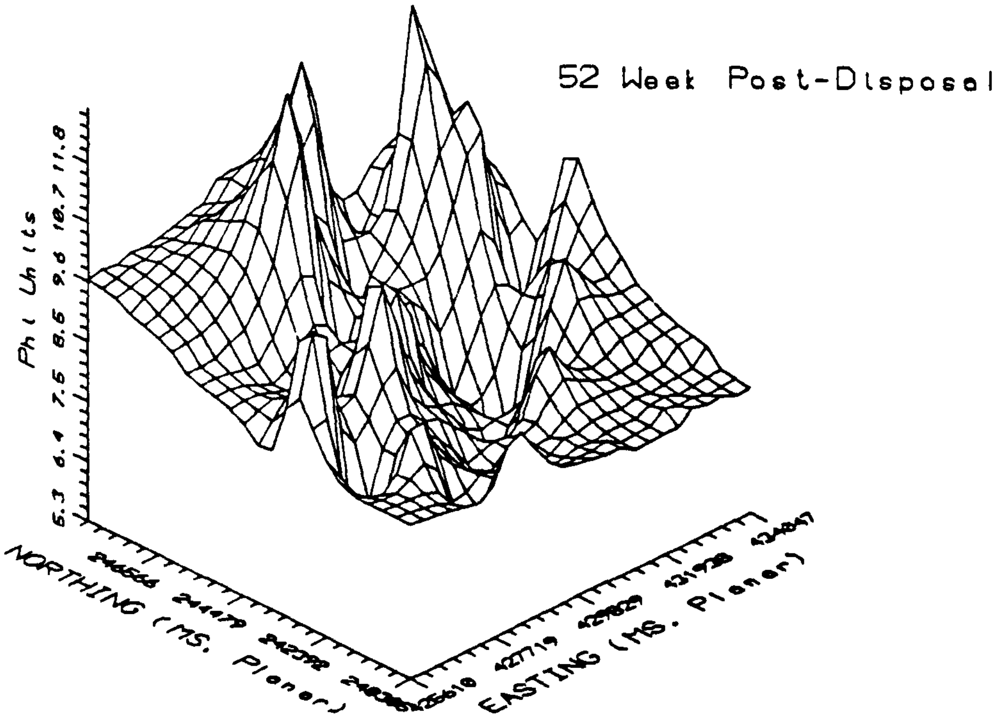


FIGURE 3.1-15. SEDIMENT GRAIN SIZE COMPOSITION AT THE GULFPORT HARBOR STUDY AREA.

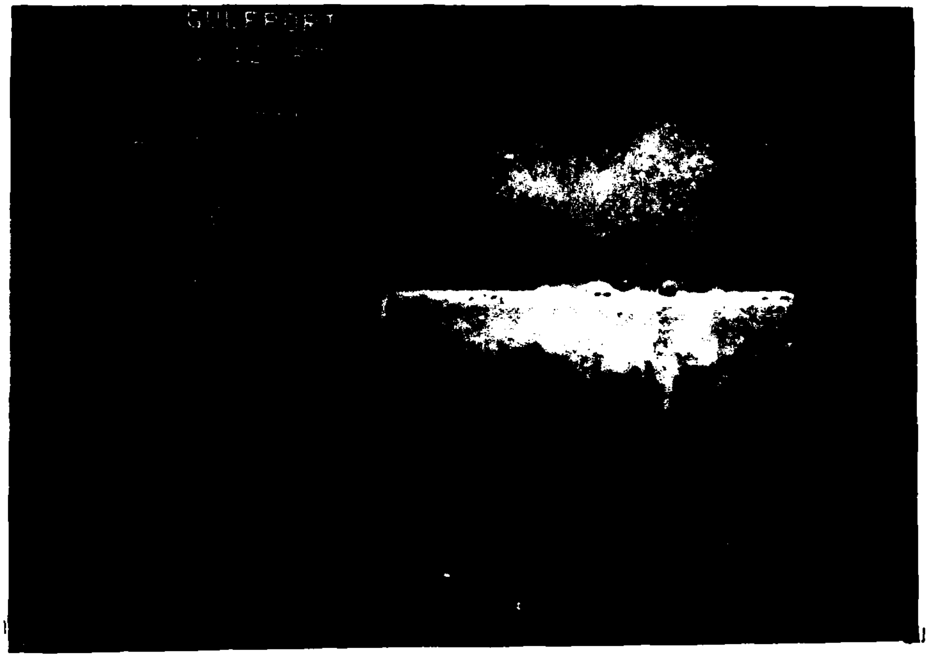
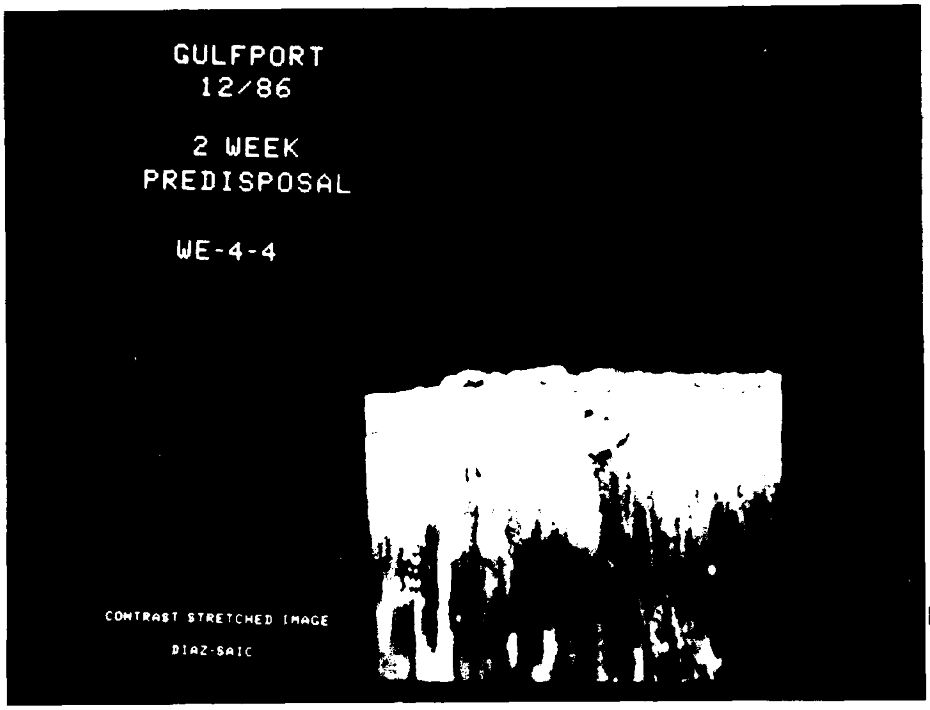


PLATE 3.1-1. REPRESENTATIVE SEDIMENT VERTICAL PROFILE IMAGES ILLUSTRATING SEDIMENT FEATURES.



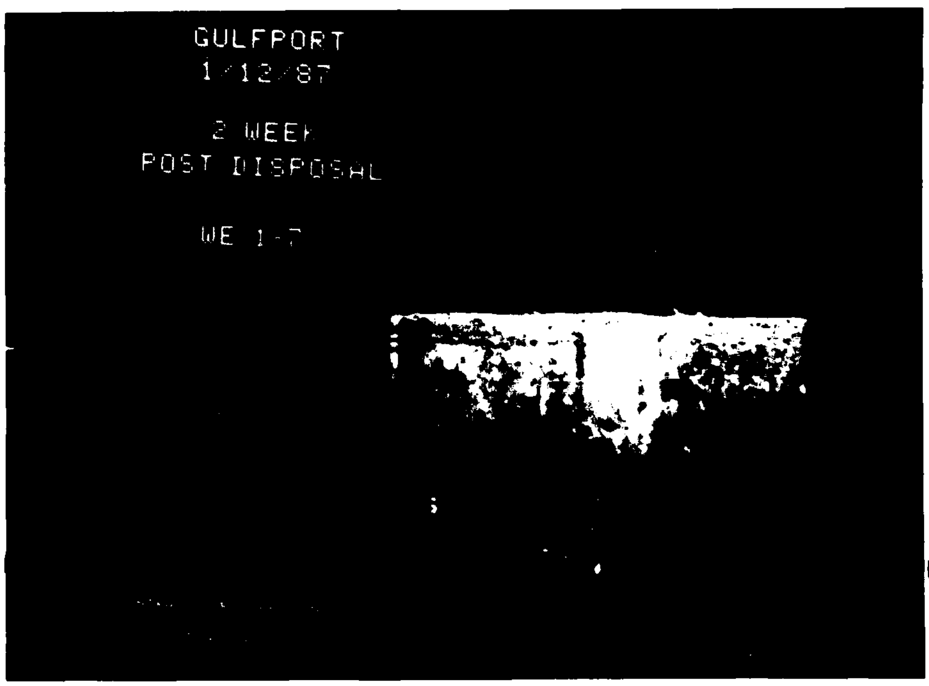


PLATE 3.1-2. SEDIMENT VERTICAL PROFILE IMAGES OF NON-IMPACTED AREAS AT GULFPORT, MISSISSIPPI.

very uniform over the entire study area. The grain size of the dredged material was the same as the background material and did not add any heterogeneity to the area.

Surface relief from all sampling periods was generally less than 1 cm. When relief was present it was usually due to a disturbed sediment, hummocks or bedform-like features. Overall sediment surface relief increased from 2 week post-disposal monitoring period to the 20 week post-disposal monitoring period at both dredged material stations and the surrounding area indicating the area was physically disturbed throughout the post-disposal period. This disturbance was attributed to wind and current induced sediment disturbance but biologically induced disturbances cannot be ruled out. Physically induced surface features were mud lumps or clay casts ranging from 0.5 cm in diameter to over 3.0 cm. Most were aerobic but a few had anaerobic surfaces suggesting a recent physical disturbance. In any case, due to the wide-spread nature of the mud lumps and their continued occurrence through the 52-week sampling, they were clearly not associated with the disposal event.

The depth of the RPD layer varied over the study area (Figure 3.1-16). Shallowest RPD values occurred at stations with disturbed surfaces and stations with little evidence of biogenic features. The deepest values were associated with burrows or other subsurface biogenic features. These differences were noted throughout the study area during the entire study. The shallowest RPD values noted were associated with the dredge materials, especially noticeable on West-East line 5.

Dredge material signatures were easily detectable in the sediment profile photographs (Plate 3.1-3). The most stations where dredge material was detected was during the 2-week post-disposal survey. Fifteen grid stations showed evidence of dredge material. Based on the photographs, the majority of the material was placed in a rectangular area bounded by stations 4-3, 5-3, 5-6 and 4-3 which corresponds well with the same detection of the materials by bathymetry (see Figure 3.1-7).

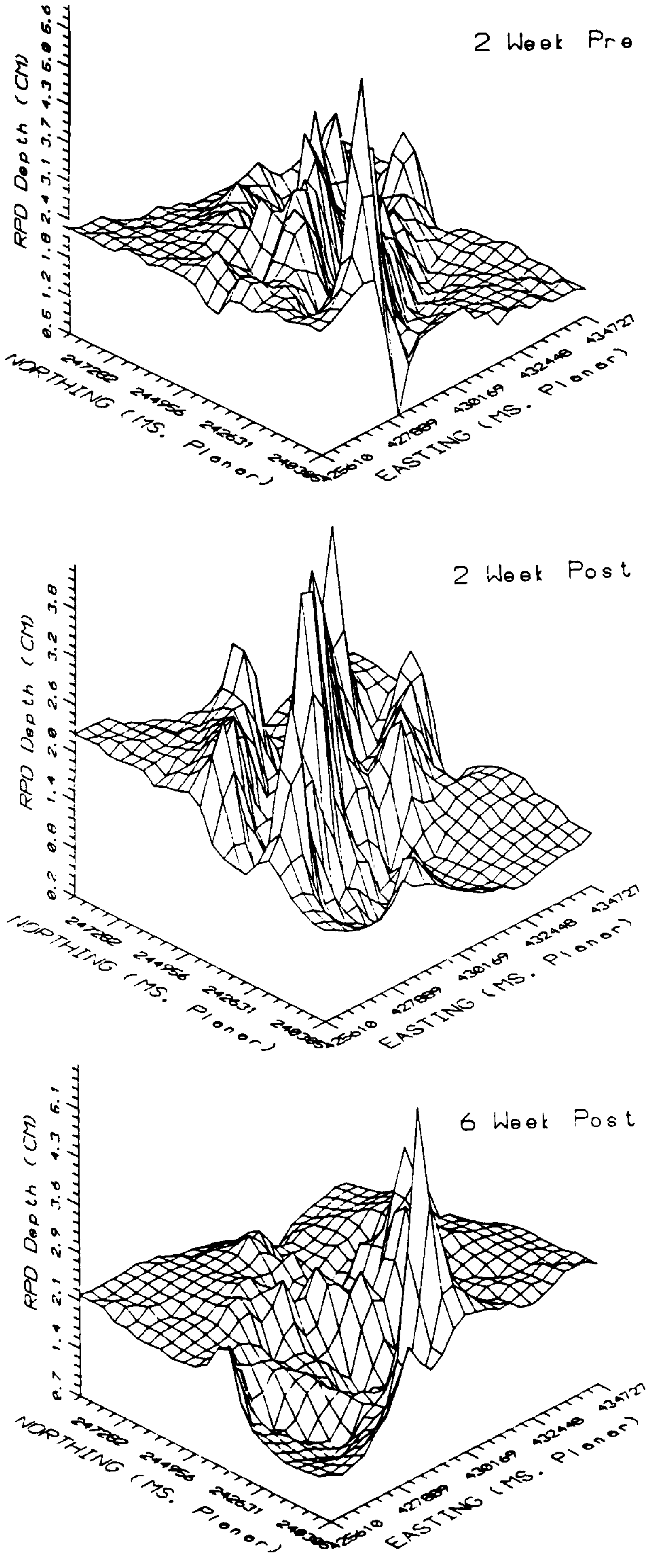


FIGURE 3.1
DISCONTINU
SITE.

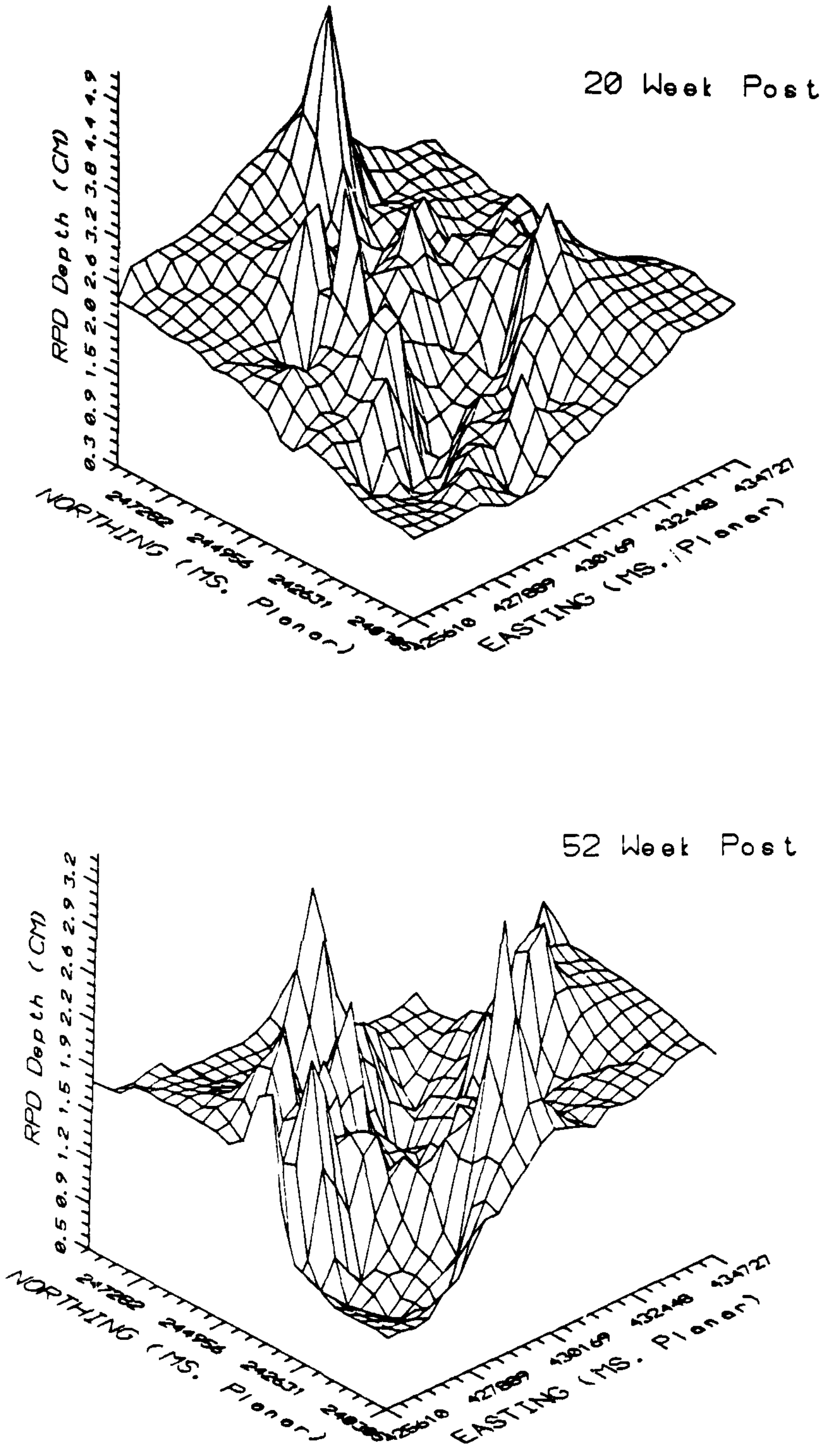


FIGURE 3.1-16. DEPTH OF REDUCED POTENTIAL DISCONTINUITY (CM) AT THE GULFPORT THIN-LAYER SITE.

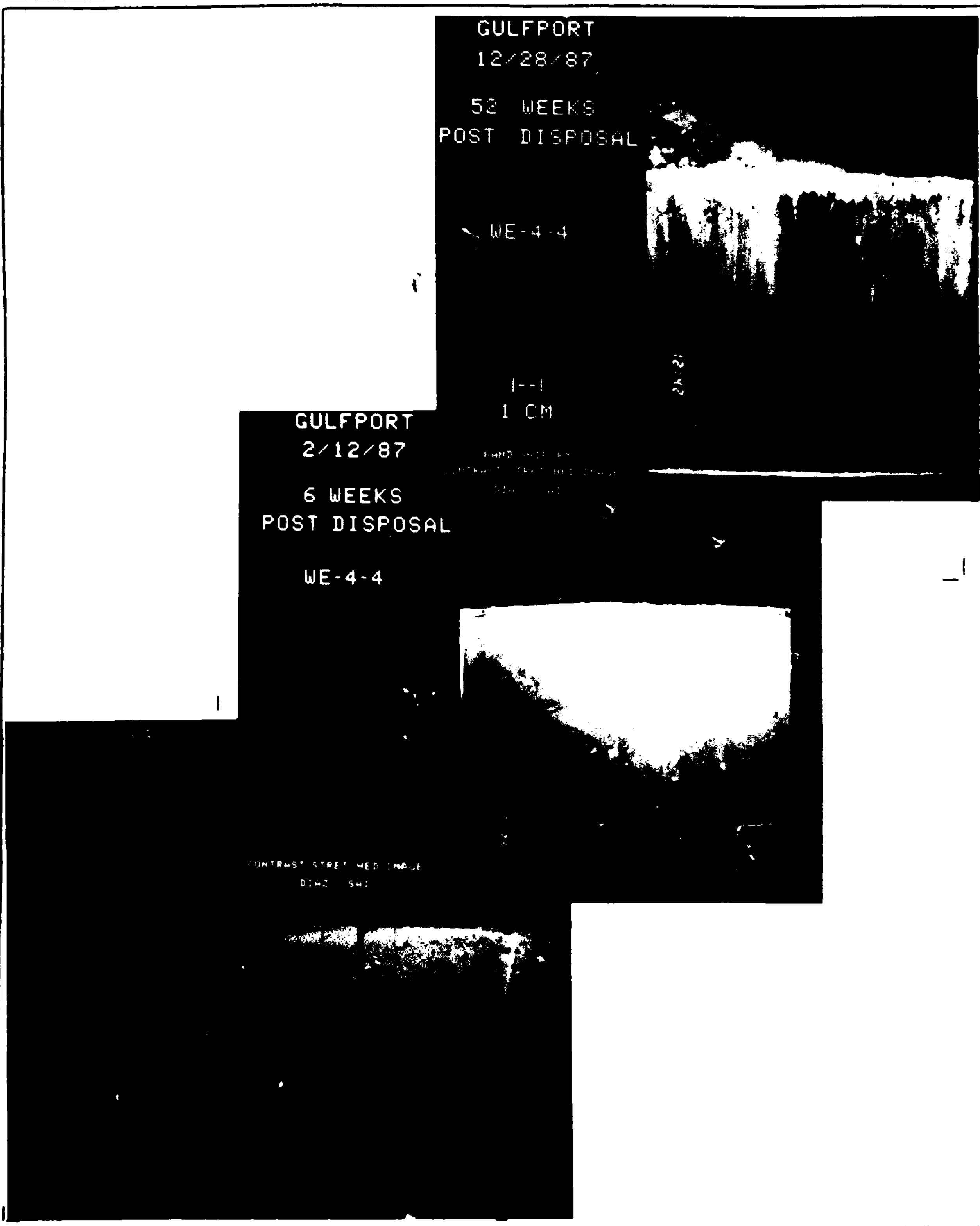


PLATE 3.1-3. SEDIMENT VERTICAL PROFILE IMAGES OF AN IMPACTED (DREDGED MATERIAL OVERBURDEN) STATION AT GULFPORT, MISSISSIPPI.

The signature of deposited materials as detected by analysis of the vertical sediment profile images slowly disappeared with time, presumably due to physical and biological reworking of the sediments (Plate 3.1-3). The material was only detectable at two stations (4-5 and 4-6) during the 20 and 52-week post disposal surveys. It should be noted that the dredged materials detected during the 52 week post-disposal survey had been extensively "weathered" and modified by biological activity. A vertically exaggerated depiction of the dredged material overburden is presented in Figure 3.1-17 for illustration.

3.2 BIOLOGICAL RESOURCES - MACROINFAUNA.

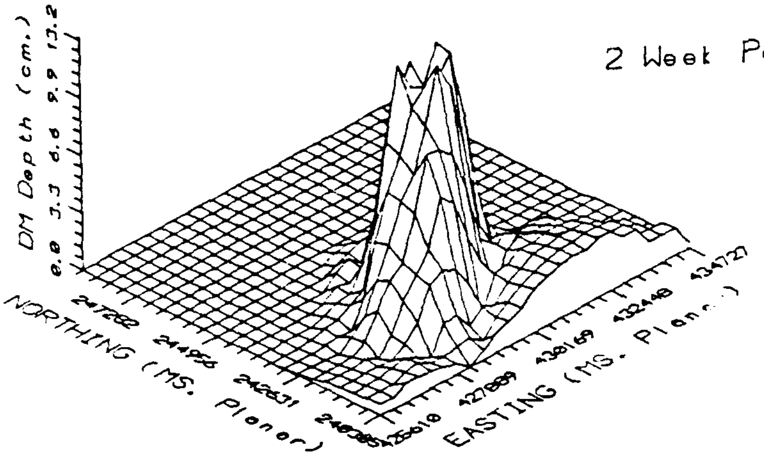
3.2.1. Macroinfauna

The results of the macroinfauna presented below represent the monthly sampling at each of sixty fixed grid stations ("fixed") and 6 stations randomly selected ("random") within each of the three design strata (Reference, fringe and disposal areas). The fixed station results represent samples consisting of a single core whereas the results of the random stations represent 8 replicate core samples. For that reason, comparisons should be made on samples that were sampled in the same manner.

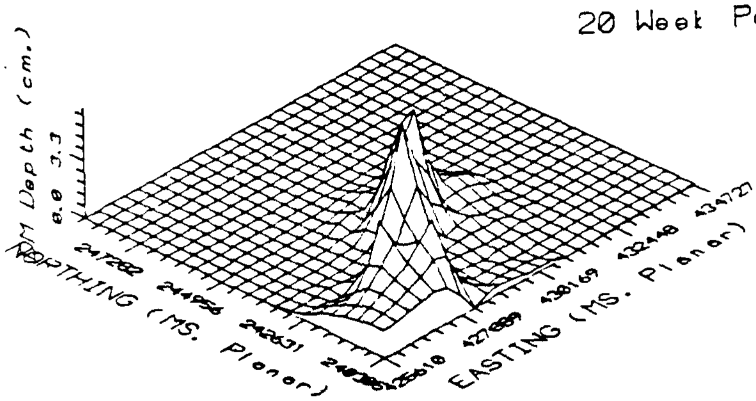
Results of the macroinvertebrate collections are presented in Appendices B and C (Part I) for the random and the fixed station collections respectively. Summary statistics, including total number of organisms $-m^{-2}$, total number of taxa per sample and Shannon/Wiener diversity index are included following each station table.

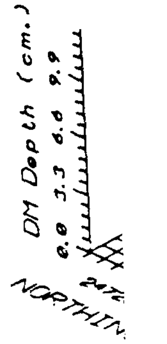
A total of 195 taxa representing 92 families of macroinvertebrates have been identified from the samples. (Table 3.2-1). Polychaetes, molluscs and crustaceans dominate the community both numerically and in terms of the number of taxa. Echinoderms and Hemichordates were occasionally dominant at some stations.

2 Week Post



20 Week Post





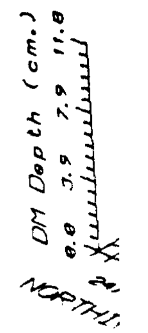


FIGURE 3.1-17.
OVERBURDEN (C
SITE.

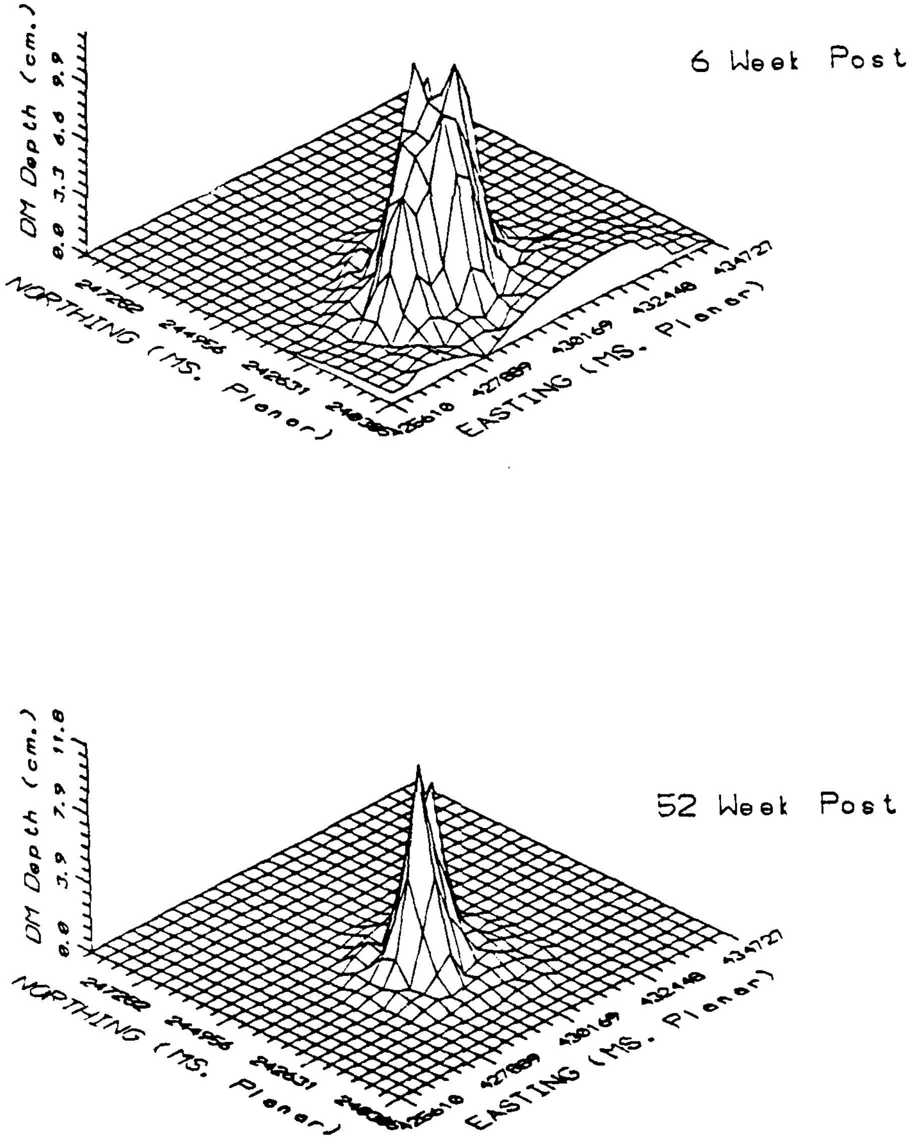


FIGURE 3.1-17. DEPTH OF DREDGED MATERIAL OVERBURDEN (CM)AT THE GULFPORT THIN-LAYER SITE.

Table 3.2-1. Phylogenetic listing of macroinfauna collected during Gulfport Harbor study.

Phylum	Class	Order	Family	Genus species
Cnidaria				
	Anthozoa			
		Actiniaria		
		Athenaria		
Platyhelminthes				
	Turbellaria			
Rhynchocoela				
Phoronida				
			Phoronidae	
				Phoronis psammophila
				Phoronis sp.
Mollusca				
	Gastropoda			
		Archogastropoda		
				Utriculastrea canaliculata
		Mesogastropoda		
			Assimineidae	
				Assiminea succinea
			Calyptraeidae	
				Crepidula fornicata
			Epitoniidae	
				Epitonium rupicola
				Epitonium sp.
			Naticidae	
				Polinices duplicata
			Pyramidellidae	
				Odostomia c.f. *bushian*
				Turbonilla amphelli
				Turbonilla curta
				Turbonilla dalli
				Turbonilla interrupta
				Turbonilla protracta
				Turbonilla sp.
			Turridae	
				Mellanella gracilis
			Vitrinellidae	
				Cyclostremicus pentagonus
		Neogastropoda		
			Nassariidae	
				Nassarius acutis

Table 3.2-1. (Continued).

Phylum	Class	Order	Family	Genus species
				Nassarius albus
				Nassarius sp.
				Nassarius vibex
		Cephalaspidea		
			Acteonidae	
				Acteon punctostriatus
			Atyidae	
				Haminoea succinea
	Opisthobranchia			
		Nudibranchia		
			Corambidae	
				Docidella obscura
	Pelecypoda			
		Arcoida		
			Aricidae	
				Anadara ovalis
				Noetia ponderosa
			Mytilidae	
				Amygdalum papyria
				Modiolus sp. A
		Nuculoida		
			Nuculinidae	
				Nuculana acuta
				Nuculana c.f. *acuta*
				Nuculana planulata
				Nuculana sp.
				Nuculana sp. A
				Nuculana sp. B
			Opalidae	
				Opalia c.f. *pumilie*
		Veneroida		
			Astartidae	
				Astarte nana
			Crassatelidae	
				Crassinella lunulata
			Montacutidae	
				Mysella c.f. *planulata*
				Mysella planulata

Table 3.2-1. (Continued).

Phylum
Class
Order
Family
Genus species

Mysella *sp*.
Ungulidae
Diplodonta *punctata*
Mactridae
Mulinia *lateralis*
Tellinidae
Macoma c.f. *tenta*
Macoma *sp*.
Macoma *tenta*
Semelidae
Abra *aequalis*
Abra *sp*.
Semele *nucliodes*
Solenidae
Solene *viridis*
Veneridae
Chione *cancellata*
Chione c.f. *latilirata*
Dosinia *elegans*
Transenella *stimpsoni*
Sayella *fusca*
Annelida
Polychaeta
Ampharetidae
Ampharete c.f. *arctica*
Ampharete *parvidentata*
Ampharete *sp*.
Melinna *conoidae*
Melinna *maculata*
Amphinomidae
Paramphinome *pulchella*
Capitellidae
Capitella *capitata*
Mediomastus *californiensis*
Mediomastus *sp*.
Notomastus *americanus*
Notomastus *daueri*
Notomastus *lobatus*
Notomastus *sp*.
Chaetopteridae
Chaetopterus *variopedatus*

Table 3.2-1. (Continued).

Phylum / Class / Order / Family / Genus species
Spiochaetopterus costarum
Spiochaetopterus oculatus
Chrysopetalidae
Bhawania heteroseta
Bhawania sp.
Paleanotus heteroseta
Paleanotus lobatus
Cirratulidae
Chaetozone sp.
Chaetozone sp. A
Cirriformia hedgpethi
Cirriformia sp.
Cirriformia sp. A
Tharyx sp.
Cossuridae
Cossura delta
Cossura soyeri
Cossura sp.
Dorvilleidae
Schistomeringos pectinata
Schistomeringos c.f. *rudolphi*
Schistomeringos rudolphi
Schistomeringos sp.
Flabelligeridae
Piromis roberti
Glyceridae
Glycera americana
Glycera c.f. *robusta*
Glycera sp.
Goniadidae
Glycinde solitaria
Glycinde sp.
Goniada carolinae
Hesionidae
Podarka obscura
Podarkeopsis levifuscina
Lumbrineridae
Lumbrineris sp.
Magelonidae
Magelona cincta

Table 3.2-1. (Continued).

- Phylum
  - Class
    - Order
      - Family
        - Genus species

- *Magelona* c.f. *pettiboneae*
- *Magelona pettiboneae*
- *Magelona sp.*
- *Magelona sp.* A
- Maldanidae
  - *Asychis elongatus*
  - *Asychis sp.*
  - *Euclymene sp.*
  - *Macroclymene zonalis*
- Nephtyidae
  - *Aglaophamus verilli*
- Nereidae
  - *Neanthes micromma*
  - *Neanthes sp.*
  - *Websterinereis tridentata*
- Onuphidae
  - *Diopatra cuprea*
- Opheliidae
  - *Armandia maculata*
  - *Ophelina cylindricaudata*
- Orbiniidae
  - *Leitoscoloplos fragilis*
  - *Leitoscoloplos robustus*
  - *Leitoscoloplos sp.*
- Oweniidae
  - *Myriochele oculata*
  - *Owenia fusiformis*
- Pectinariidae
  - *Pectinaria gouldii*
- Phyllodocidae
  - *Eteone heteropoda*
  - *Eteone lactea*
  - *Phyllodoce arenae*
- Pilargidae
  - *Ancistrosyllis groenlandica*
  - *Ancistrosyllis jonesi*
  - *Ancistrosyllis papillosa*
  - *Ancistrosyllis sp.*
  - *Cabira incerta*
  - *Parandalia americana*
  - *Sigambra bassi*
  - *Sigambra sp.*

Table 3.2-1. (Continued).

Phylum	Class	Order	Family	Genus species
				Sigambra tentaculata
				Sigambra wassi
			Polynoidae	
				Harmothoe sp.
				Lepidasthenia sp. A
				Lepidasthenia sp. B
				Lepidonotus sublevis
				Malmgreniella sp.
				Malmgreniella sp. A
				Malmgreniella sp. B
			Polyodontidae	
				Polyodontes lupinus
			Sabellidae	
				Megalomma bioculatum
				Megalomma sp.
				Potamilla c.f. *reniformis*
				Potamilla sp.
			Sigalionidae	
				Sthenelais limicola
				Sthenelais sp.
				Sthenelais sp. A
			Spionidae	
				Apoprionospio pygmaea
				Apoprionospio sp.
				Carazziella hobsonae
				Paraprionospio pinnata
				Polydora caulleryi
				Polydora cornuta
				Polydora c.f. *caulleryi*
				Polydora socialis
				Polydora sp. A
				Polydora sp. B
				Polydora websteri
				Prionospio cirrifera
				Prionospio c.f. *cirrifera*
				Prionospio pygmaea
				Prionospio sp.
				Spiophanes bombyx
				Spiophanes sp.
				Streblospio benedicti

Table 3.2-1. (Continued).

Phylum / Class / Order / Family / Genus species
Syllidae
Terebellidae
Amaesea mitchilli
Loimia medusa
Loimia sp.
Polycirrus sp.
Oligochaeta
Hirudinea
Sipuncula
Golfingiidae
Phascolion sp.
Phascolion strombi
Arthropoda
Crustacea
Malacostraca
Stomatopoda
Squillidae
Squilla empusa
Cumacea
Bodotriidae
Cyclaspis varians
Leuconidae
Eudorella monodon
Leucon americanus
Diastylidae
Oxyurostylis smithi
Amphipoda
Ampeliscidae
Ampelisca sp.
Ampelisca sp. A
Ampelisca sp. B
Ampelisca vadorum
Aoridae
Grandidierella bonnieroides
Argissidae
Argissa hamatipes
Corophiidae
Corophium acherusicum
Corophium tuberculatum
Corophium sp A
Bateidae
Batea catherinensis

Table 3.2-1. (Continued).

Phylum
Class
Order
Family
Genus species

Lilljeborgiidae
Listriella barnardi
Photidae
Microprotopus ranei
Stenothidae
Parametopella texensis
Mysidacea
Mysidacidae
Mysidopsis sp.
Decapoda
Penaeidea
Penaeidae
Trachypenaeus constrictus
Trachypenaeus similis
Trachypenaeus sp.
Caridea
Alpheidae
Alpheus heterochaelis
Ogyrididae
Ogyrides alphaerostris
Anomura
Paguridae
Pagurus annulipes
Brachyura
Portunidae
Callinectes sapidus
Callinectes similis
Pinnotheridae
Pinnixa pearsei
Pinnixa sp.
Xanthidae
Eurypanopeus depressus
Panopeus obesus
Echinodermata
Holothuroidea
Dendrochirotida
Cucumaridae
Allothyone mexicana

Table 3.2-1. (Continued).

Phylum	Class	Order	Family	Genus species
			Synaptidae	
				Leptosynapta crassipatina
	Stelleroidea			
		Ophiuroidea		
			Ophiuridae	
				Hemipholis elongata
				Microphiopholis atra
Hemichordata				
			Ptychoderidae	
				Balanoglossus c.f. *aurantiacus*
Cephalochordata				
				Branchiostoma sp.
Chordata				
	Vertebrata			
	Osteichthyes			
		Anguilliformes		
			Ophichthidae	
				Myrophis punctatus
		Perciformes		
			Gobiidae	
		Pleuronectiformes		
			Cynoglossidae	
				Symphurus plagiusa

Fixed Stations

Benthic macroinvertebrate density varied widely in the fixed stations both spatially and temporally (Figure 3.2-1). The range of total macroinfauna abundance went from a high of 9,205 individuals $-m^{-2}$ in December 1986 (pre-disposal, reference station 5-1) to a low of 396 individuals $-m^{-2}$ at stations 4-4 (2-week post-disposal, disposal area) in January 1987. The lowest abundances were generally found in the disposal area, two weeks after the disposal event. Abundances generally ranged in the 2,000 - 3,000 organisms $-m^{-2}$ for all five sampling events (Figure 3.2-2). During the five surveys, there was generally a decreasing trend in total average macroinfauna abundances. With the exception of the May sampling period (20-week post-disposal) the disposal area stations showed lowest average abundances when compared to the other strata. The number of species (per sample) showed marked variations across both stations and times (Figure 3.2-3). The number of species ranged from a low of 6 taxa at fixed station 4-1 (reference area) during the 20-week post-disposal sampling event to a high during the predisposal (December 1986) sampling trip of 35 taxa at station 3-5. Generally, the numbers of taxa were highest during the predisposal period and decreased slightly with each sampling event through May 1987 (20-week post-disposal). The number of taxa (per sample) remained, for the most part, between 20 and 26 taxa per core (Figure 3.2-4). The number of species at several stations (4-3, 4-4, 4-5 and 5-3) in the disposal and adjacent fringe areas dropped to 10-11 species during the two-week post-disposal sampling. These same stations were the same ones that had correspondingly low numbers of individuals.

Shannon-Weiner diversity ranged from a low of 1.18 at station 4-1 in May 1987 (20-week post-disposal) to a high of 4.27 at station 3-5 during the predisposal sampling (December 1986) as shown in Figure 3.2-5. This parameter showed less variability than either the total abundance or number of species.

A total of 113 taxa were identified from the 2-week predisposal survey (December 1986). The polychaetes Armandia maculata, Podarkeopsis levifuscina, Sigambra tentaculata, and Paramphinome pulchella, the brittle star (Ophiuridae) Microphiopholis atra and the acorn worm (Hemichordata)

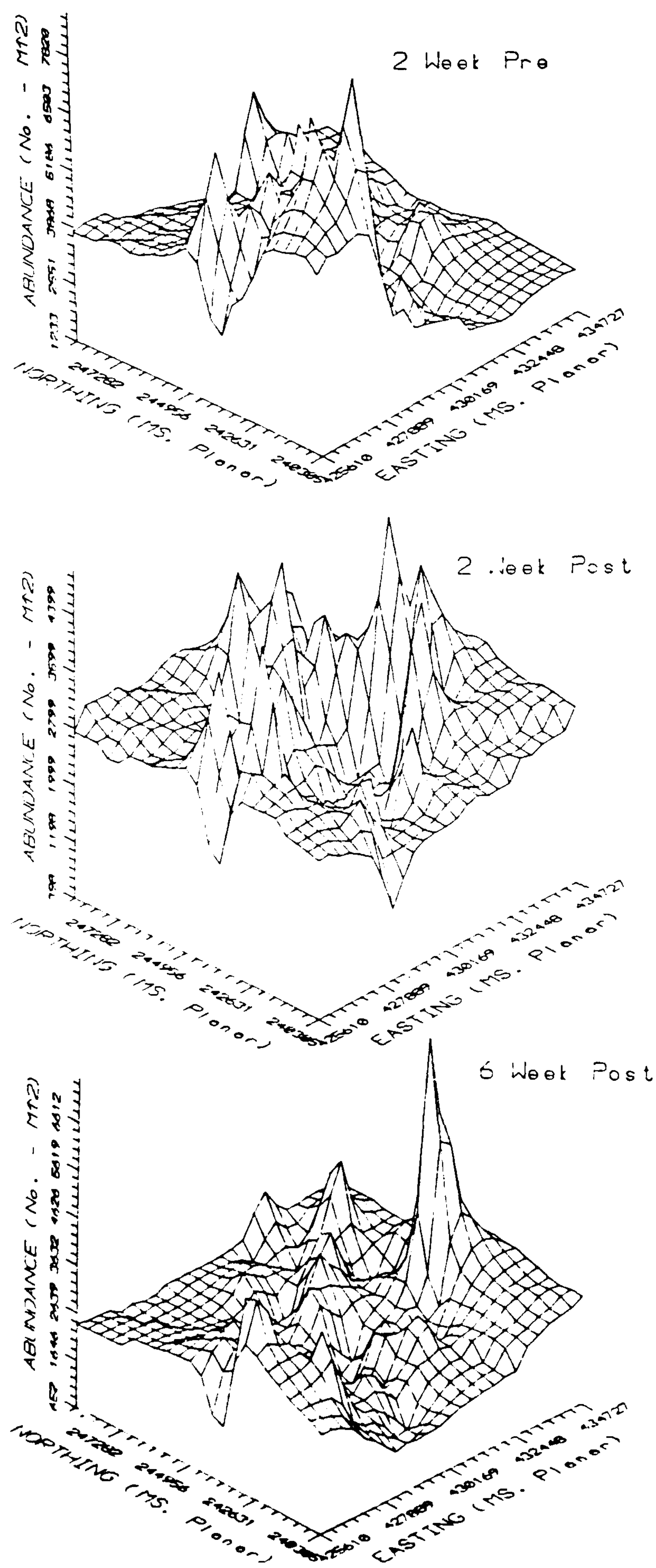


FIGURE 3.2–
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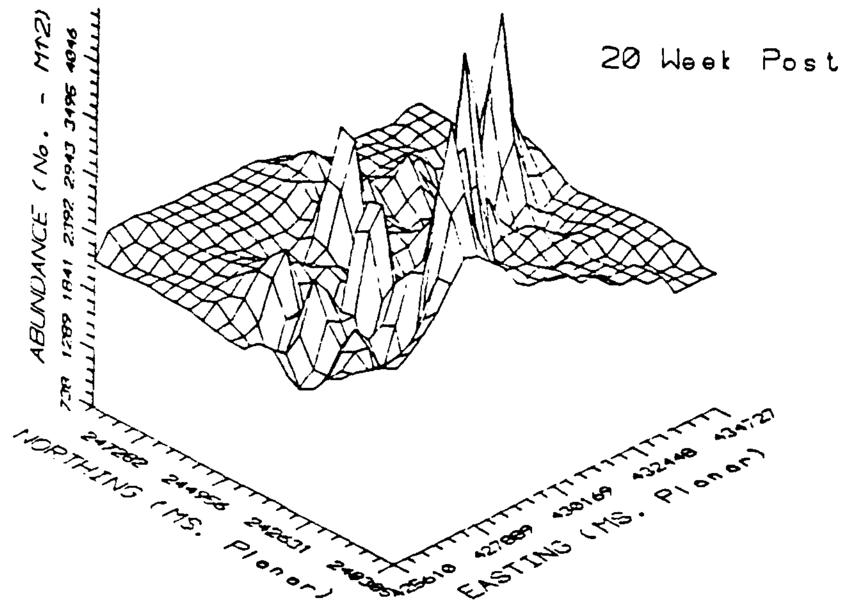

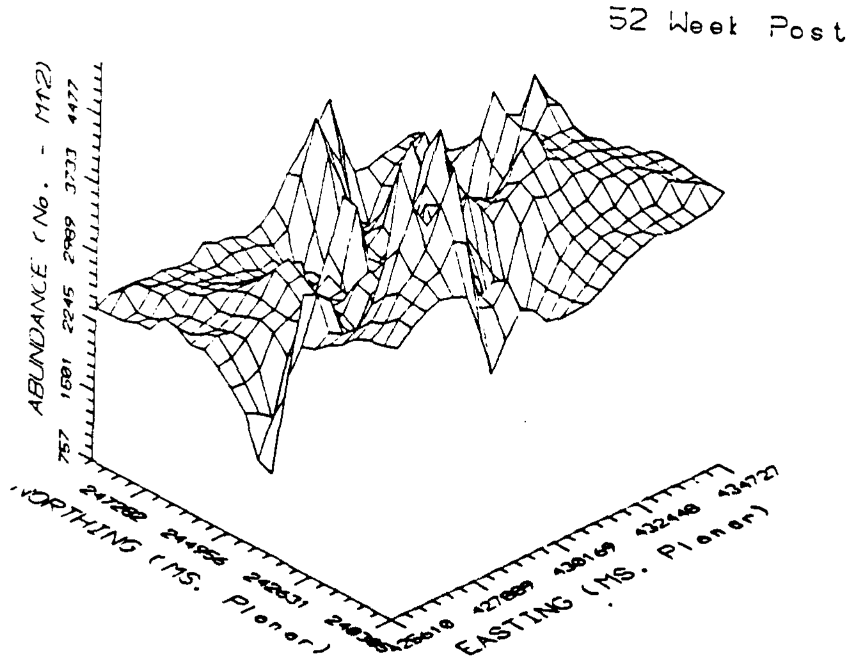

FIGURE 3.2-1. TOTAL ORGANISM ABUNDANCE AT THE GULFPORT HARBOR FIXED STATIONS. (Number – M-2)

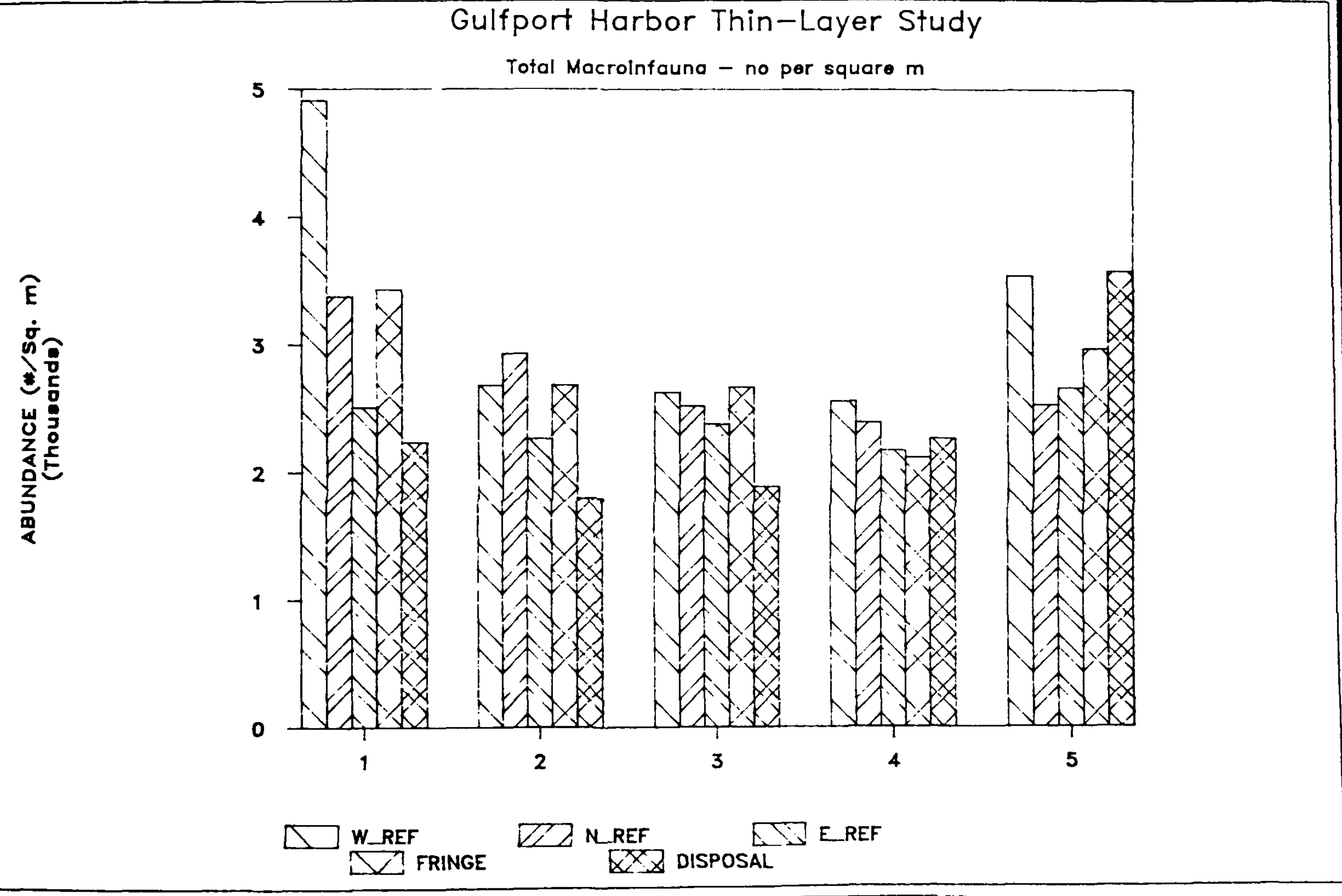

FIGURE 3.2-2. AVERAGE ABUNDANCE OF MACROINFAUNA AT THE VARIOUS SAMPLING AREAS. (Based on Fixed Station Data).

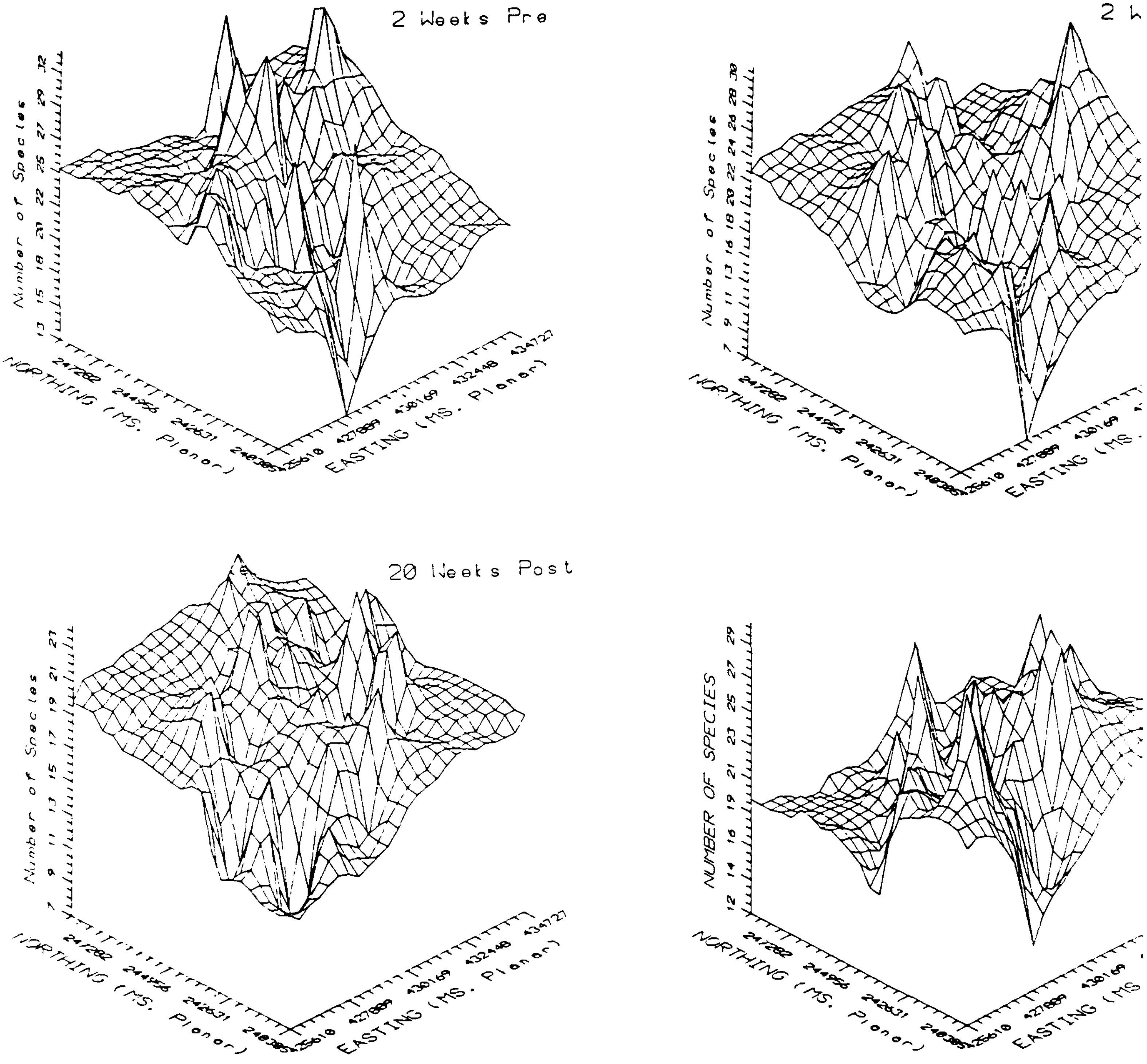

FIGURE 3.2-
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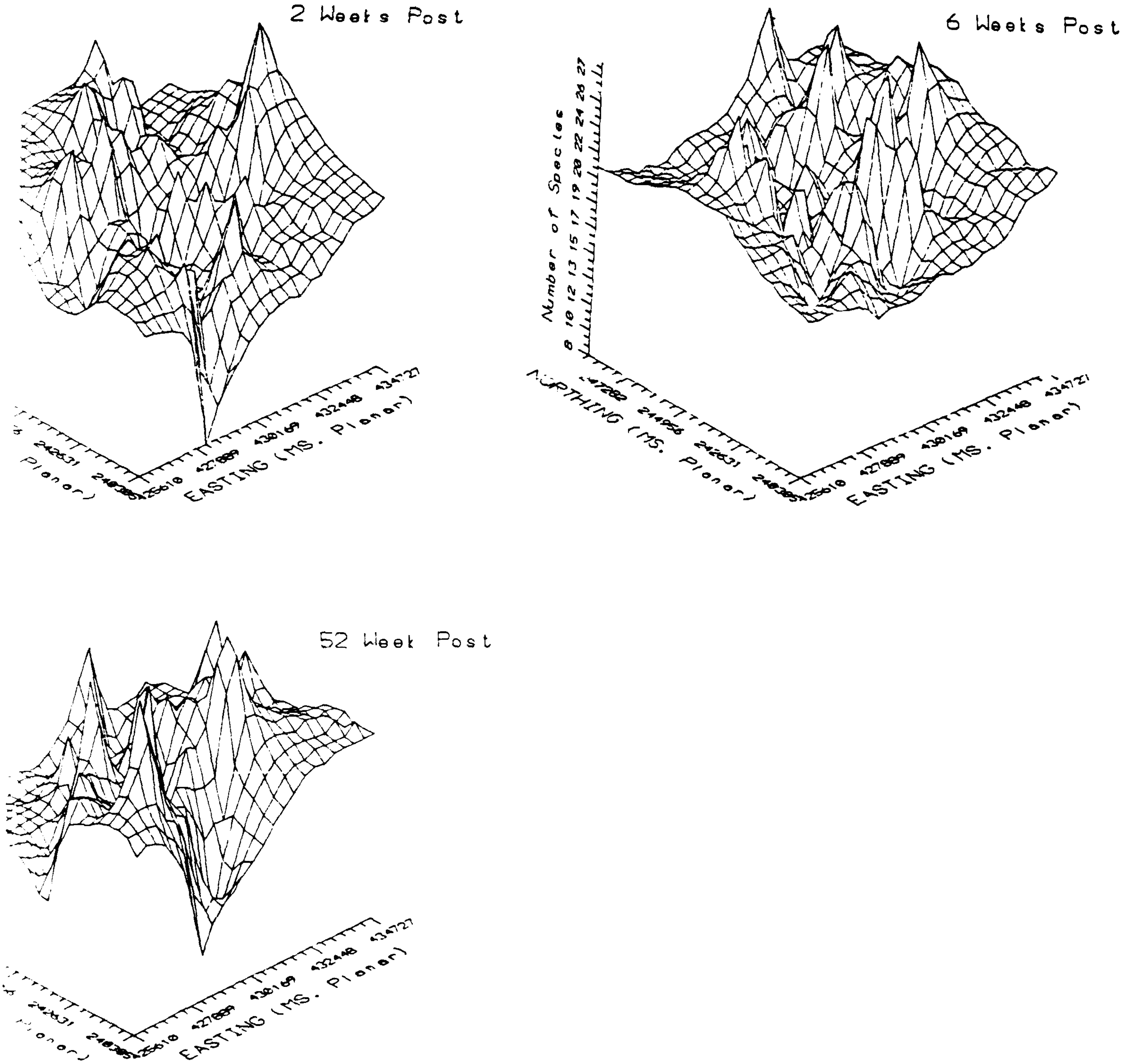


FIGURE 3.2-3. NUMBER OF INFAUNA SPECIES COLLECTED (PER BOX CORE) AT THE GULFPORT HARBOR FIXED STATIONS.

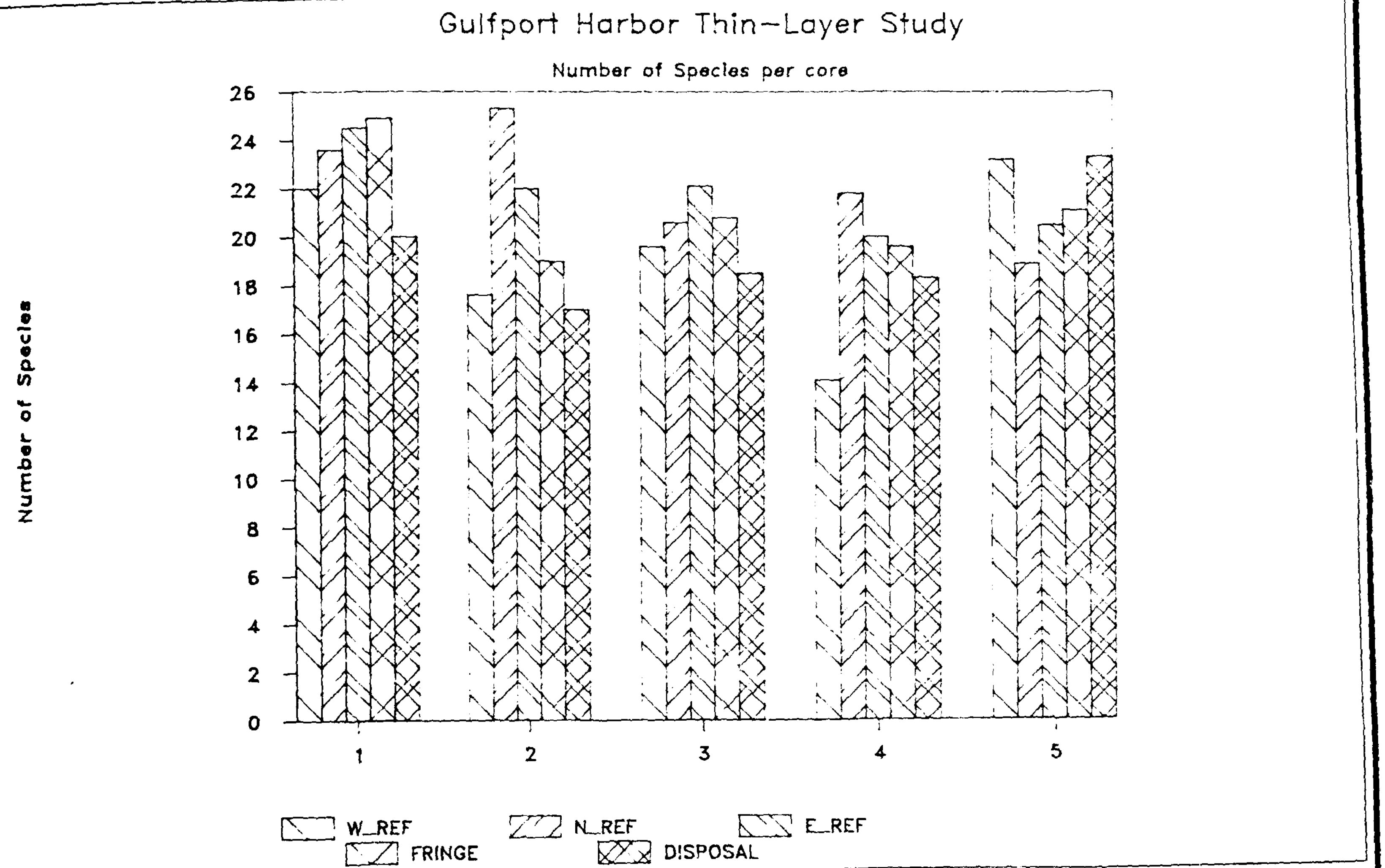


FIGURE 3.2-4. NUMBER OF SPECIES AT THE VARIOUS SAMPLING AREAS BASED ON FIXED STATION DATA.

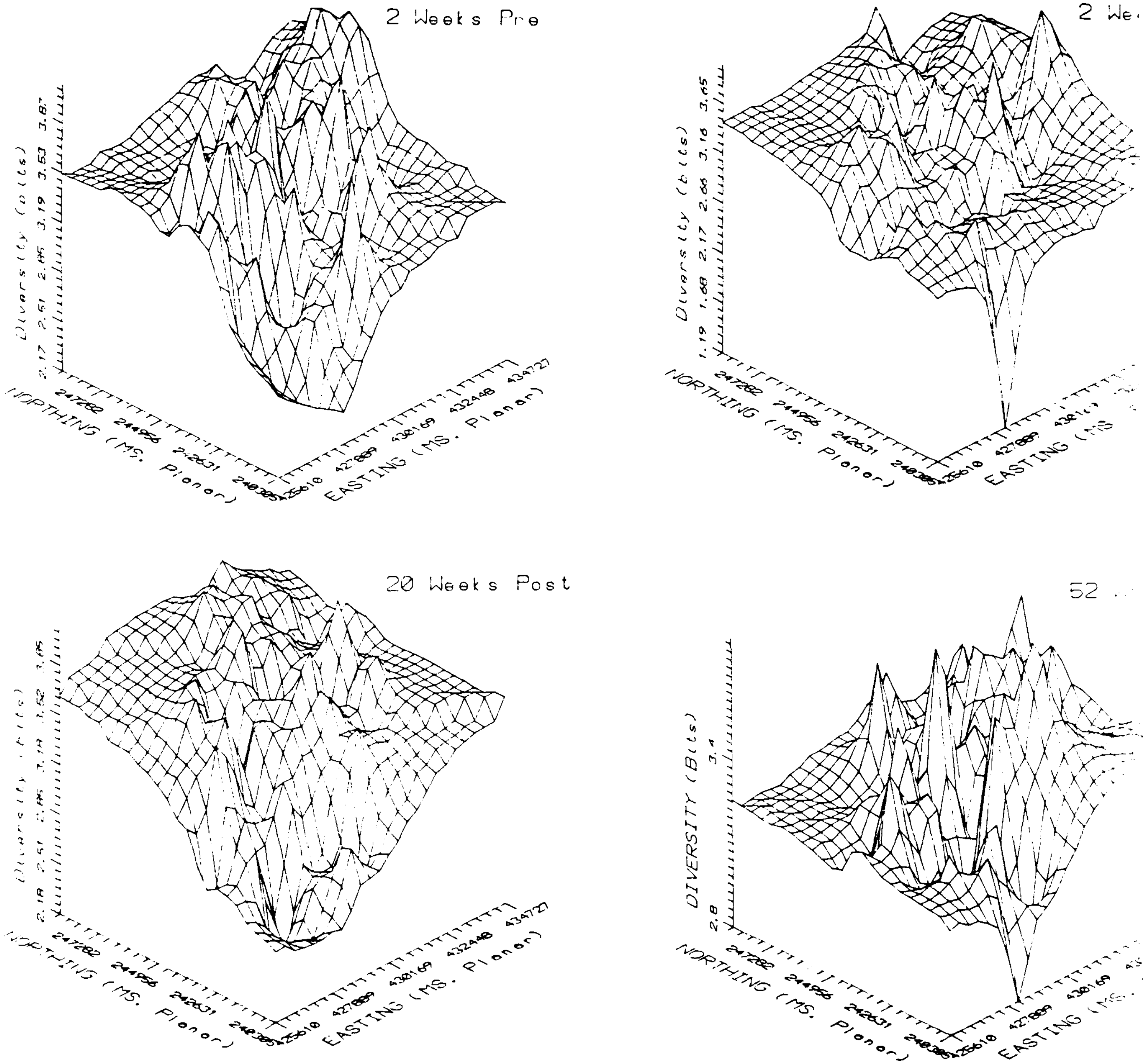


FIGURE 3.2-5. S
INDEX AT THE GU
FIXED STATIONS.

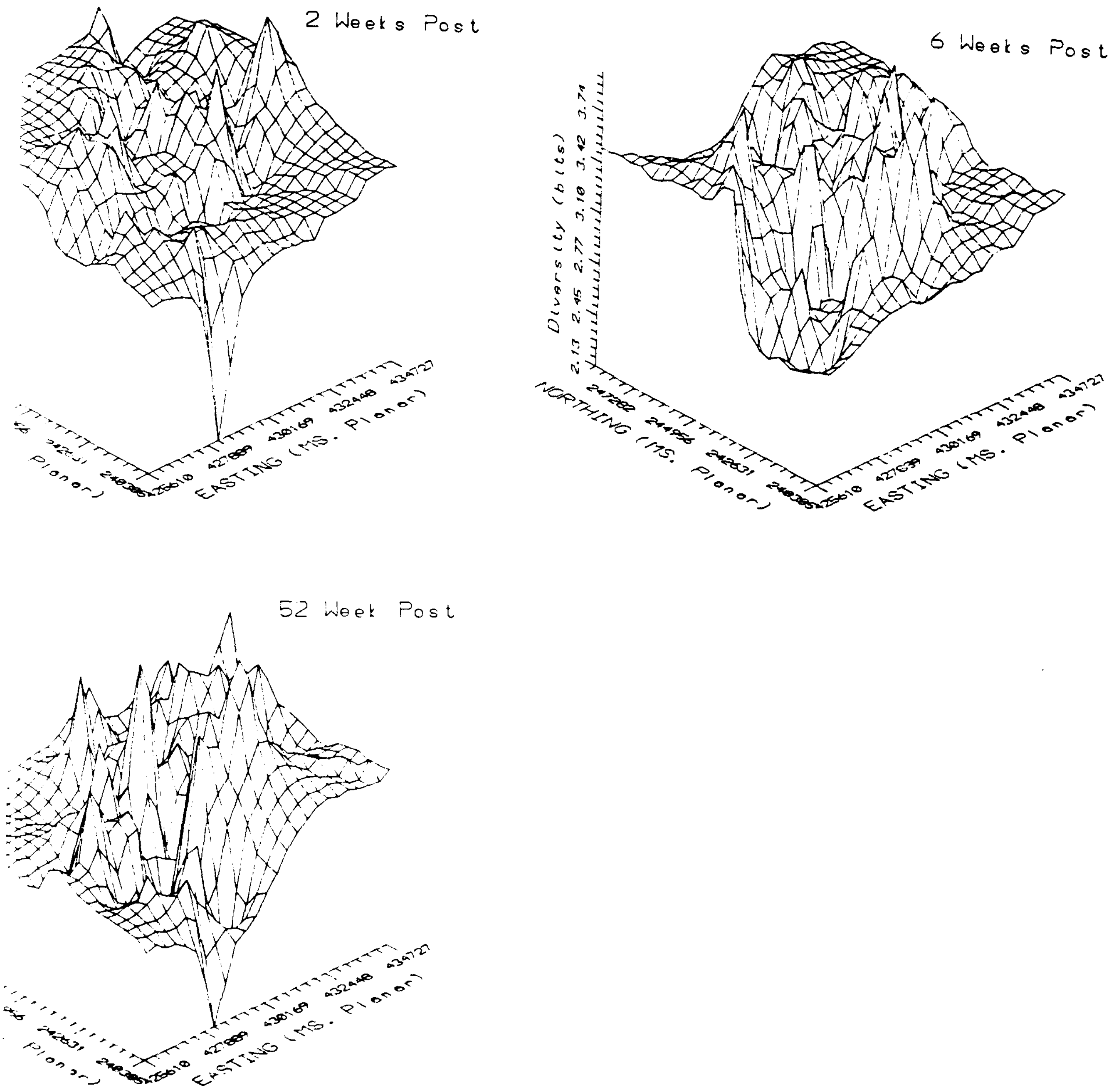


FIGURE 3.2-5. SHANNON-WEINER DIVERSITY INDEX AT THE GULFPORT HARBOR STUDY FIXED STATIONS.

Balanoglossus c.f. aurantiacus were the dominant taxa. Overall, Armandia maculata was the dominant species numbering from about 500 to over 4,000 individuals $-m^{-2}$ on a station basis. A large amount of species variability existed throughout the study area.

One hundred four (104) taxa were from the 2-week post-disposal sampling effort (January 1987). Armandia maculata was again the dominant organism although numbering somewhat lower (500 to 2,000 organisms $-m^{-2}$) than during the 2-week predisposal sampling. Generally, the most common taxa were the same as during predisposal with the addition of the Rhynchocoela (LPIL) as a dominant after Armandia maculata.

Sampling during the 6-week post-disposal period (February 1987) yielded 100 taxa from the fixed station grid. Armandia maculata and Paramphinome pulchella were still dominant with Sigambra tentaculata, Microphiopholis atra and Balanoglossus c.f. aurentiacus.

Twenty-week post-disposal sampling (May 1987) resulted in the collection of 83 macroinfauna taxa with Rhynchocoela and Sigambra tentaculata becoming the most numerous forms. The Cnidarian Actinaria was found in large numbers at most stations along with the usual Podarkeopsis levifuscina, Microphiopholis atra and Paramphinome pulchella. Armandia maculata was found to occur at only four stations in very low abundance during this sampling trip.

The 52-week post-disposal sampling produced 113 taxa with Rhynchocoela and Mediomastus ambiseta at the dominant organisms. Armandia maculata was present in low numbers but was not a dominant during this sampling period. This change in dominance possibly represents an annual shift due to changes in hydrographic regimes from the previous year.

Spatial Analysis

The fixed station data lends itself to display of two and three-dimensional surface trend plots providing there are enough stations to provide a meaningful display. For the Gulfport Harbor Thin-layer study, abundances of five taxa were sufficient to prepare plots. These taxa were Armandia maculata, Sigambra tentaculata, Podarkeopsis levifuscina, Balanoglossus c.f.

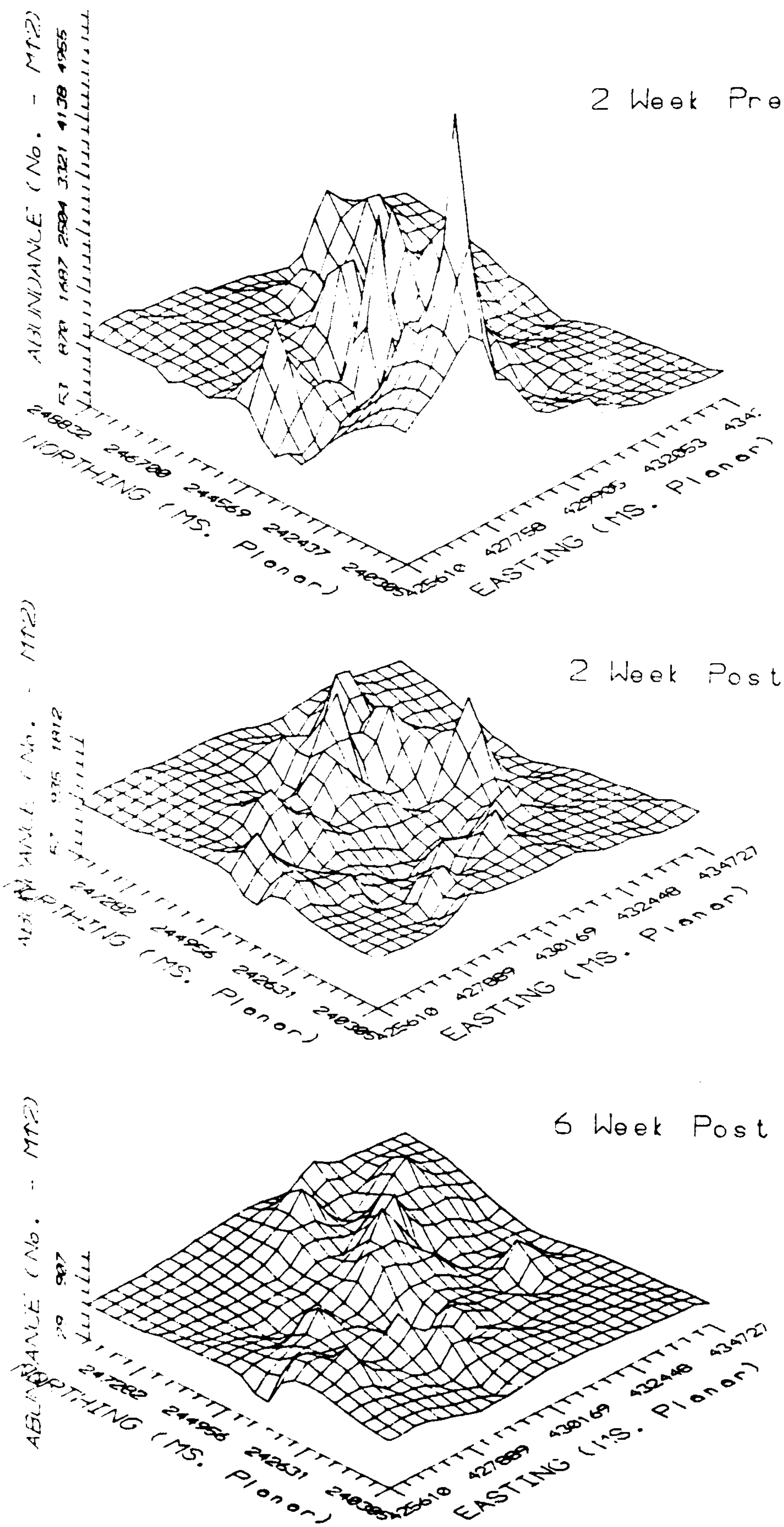
aurentiacus and Microphiopholis atra and are presented respectively in Figures 3.2-6 through 3.2-10.

Armandia maculata (Figure 3.2-6) displayed large spatial variability with the highest densities generally occurring in the central portion of the study area, especially during the 2-week predisposal period. A notable decline in Armandia abundance is noted during the two-week post-disposal survey in the disposal area. A slight recovery is noted during the 6-week post-disposal survey during a period of general decline of the organism throughout the study area. By the 20-week and 52-week post-disposal samplings, Armandia is absent from most of the study area. There were significant spatial (station) and temporal (sampling period) differences in this species as determined by ANOVA (Table 3.2-2). Spatially, significantly fewer Armandia were found in the disposal area during the 2-week post-disposal sampling.

The abundance of Sigambra tentaculata was highest during the 2-week post-disposal period with abundances >1,800 organisms $-m^{-2}$ occurring in the un-impacted south eastern quadrant of the study area (Figure 3.2-7). By ANOVA, this species showed only a significant temporal (seasonal) variation with highest numbers found during the 52-week (January 1988) post-disposal survey. Overall, lowest abundance of this species was during the 6-week post-disposal period (February 1987).

Podarkeopsis levifuscina displayed its highest abundance in the central portion of the study area for all the periods sampled (Figure 3.2-8). A general decline in numbers paralleling the decline seen in total macroinfauna abundance was the most notable feature in these displays. By ANOVA, this species showed significant spatial and temporal variation with the lowest numbers found in the southwestern reference area and in the disposal area. All areas had significantly lower numbers of Podarkeopsis during the 52-week post-disposal sampling.

The Hemichordate Balanoglossus c.f. aurantiacus showed a highly variable pattern for the first three surveys (Figure 3.2-9). Sharp peaks were noted slightly north east of the central portion of the study area. A general



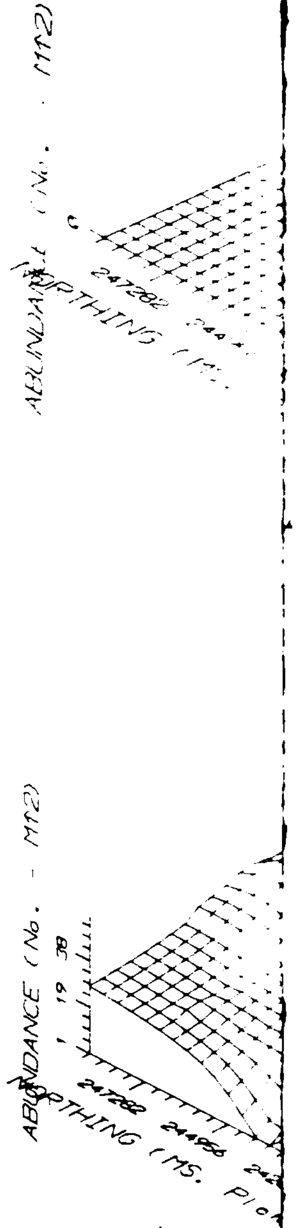


FIGURE 3.2–6. ABUNDAN
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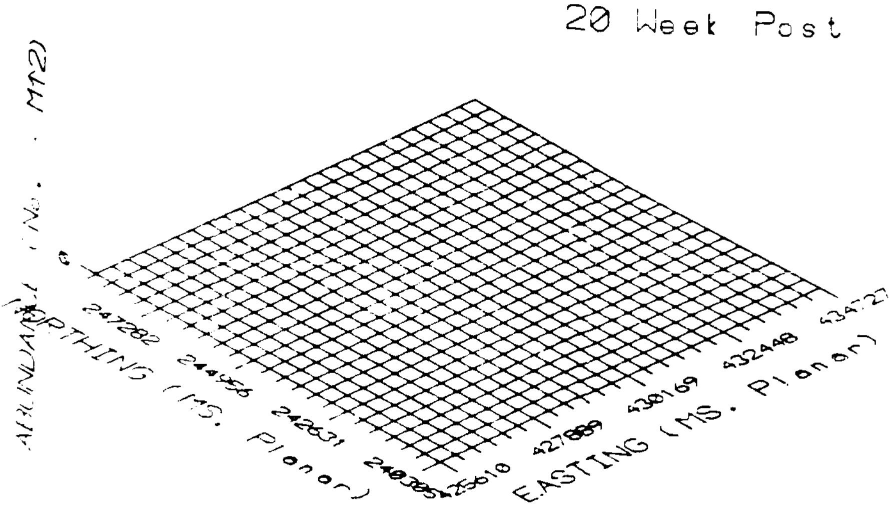


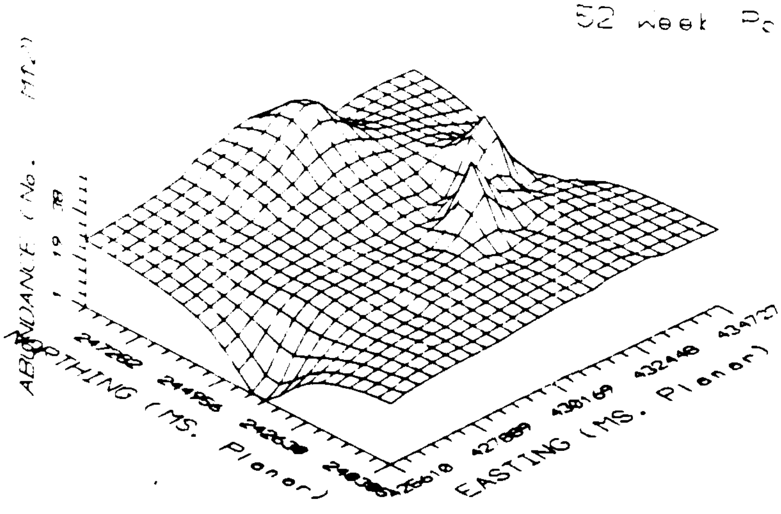
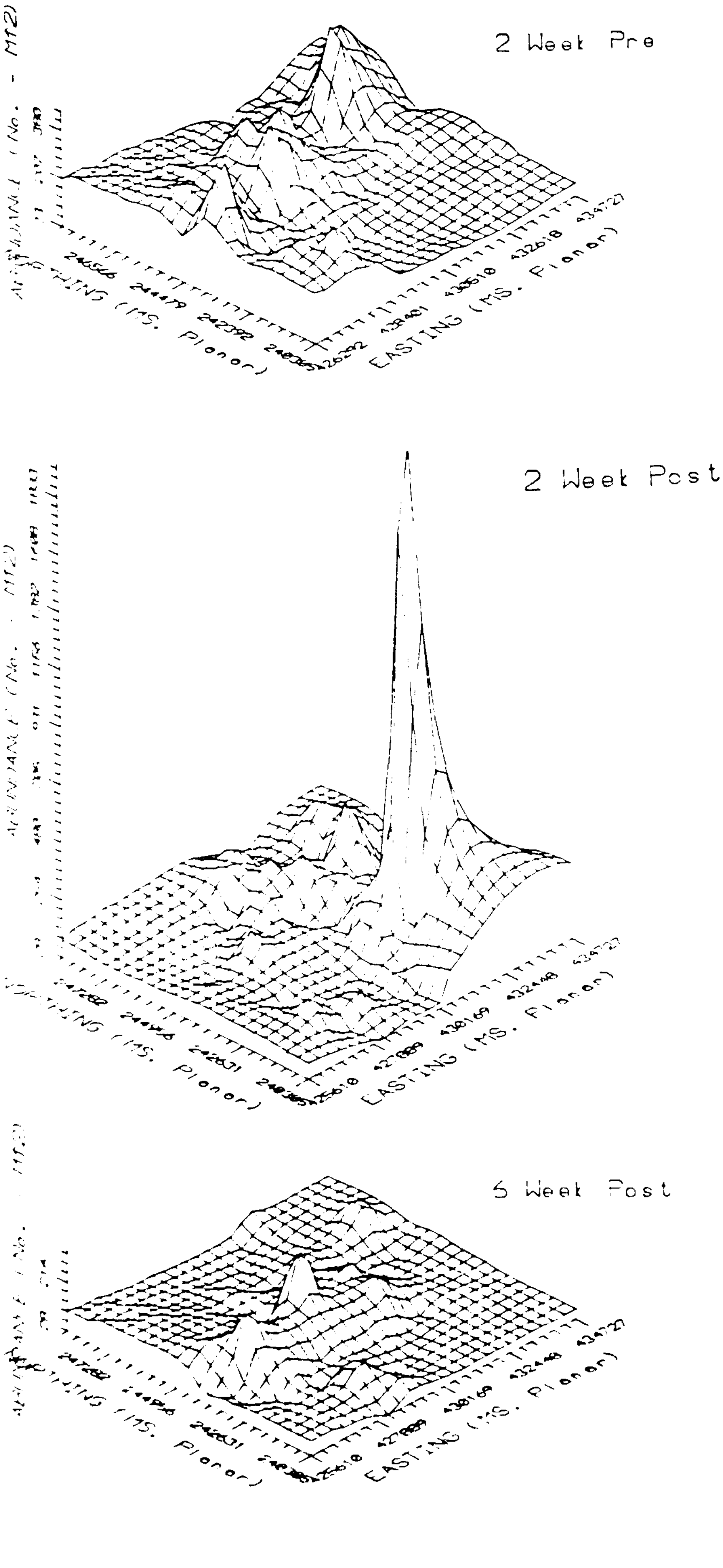


FIGURE 3.2-6. ABUNDANCE OF ARMANDIA MACULATA (POLYCHAETA : OPHELIDAE) AT THE GULFPORT HARBOR STUDY



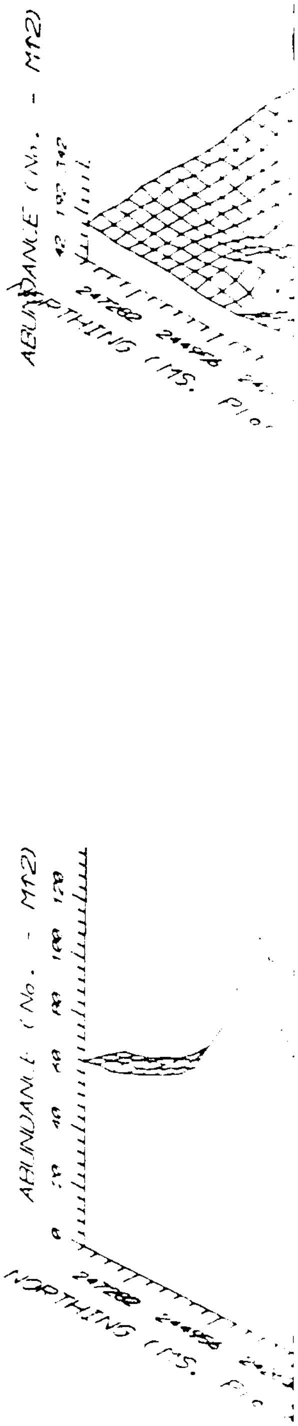


FIGURE 3.2-7. ABUND
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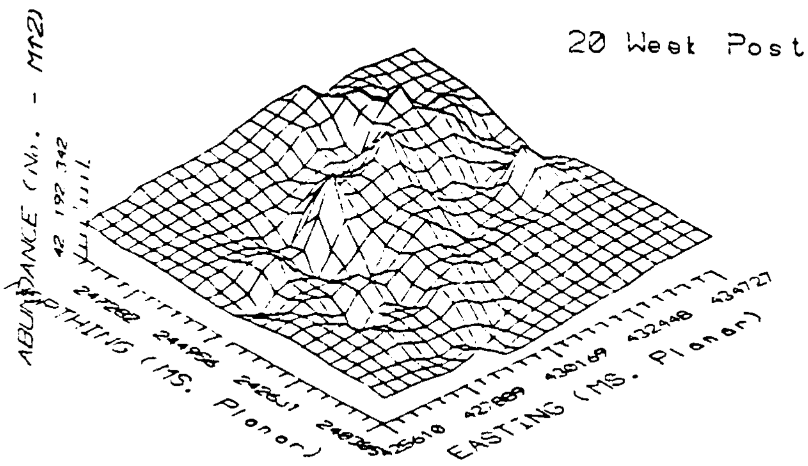


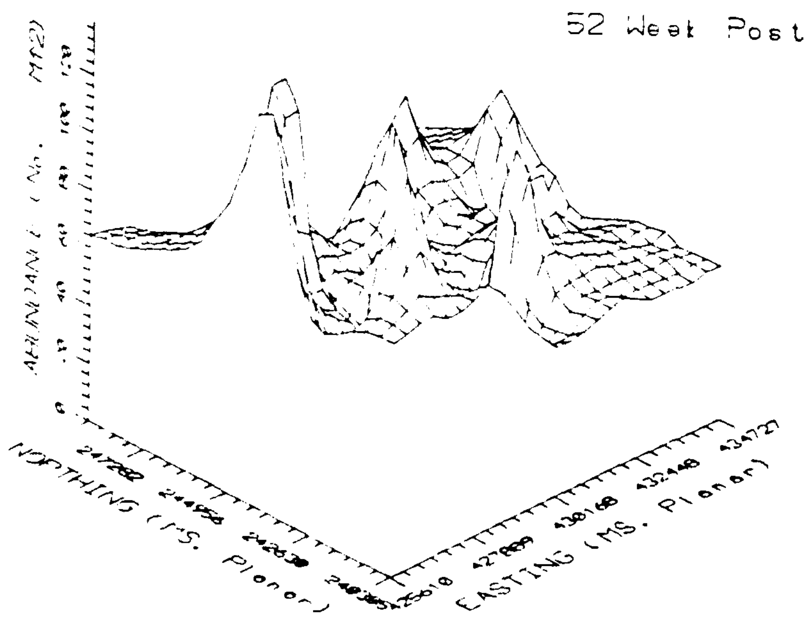


FIGURE 3.2-7. ABUNDANCE OF SIGAMBRA TENTACULATA (POLYCHAETA:PILARGIDAE) AT THE GULFPORT HARBOR FIXED STATIONS.

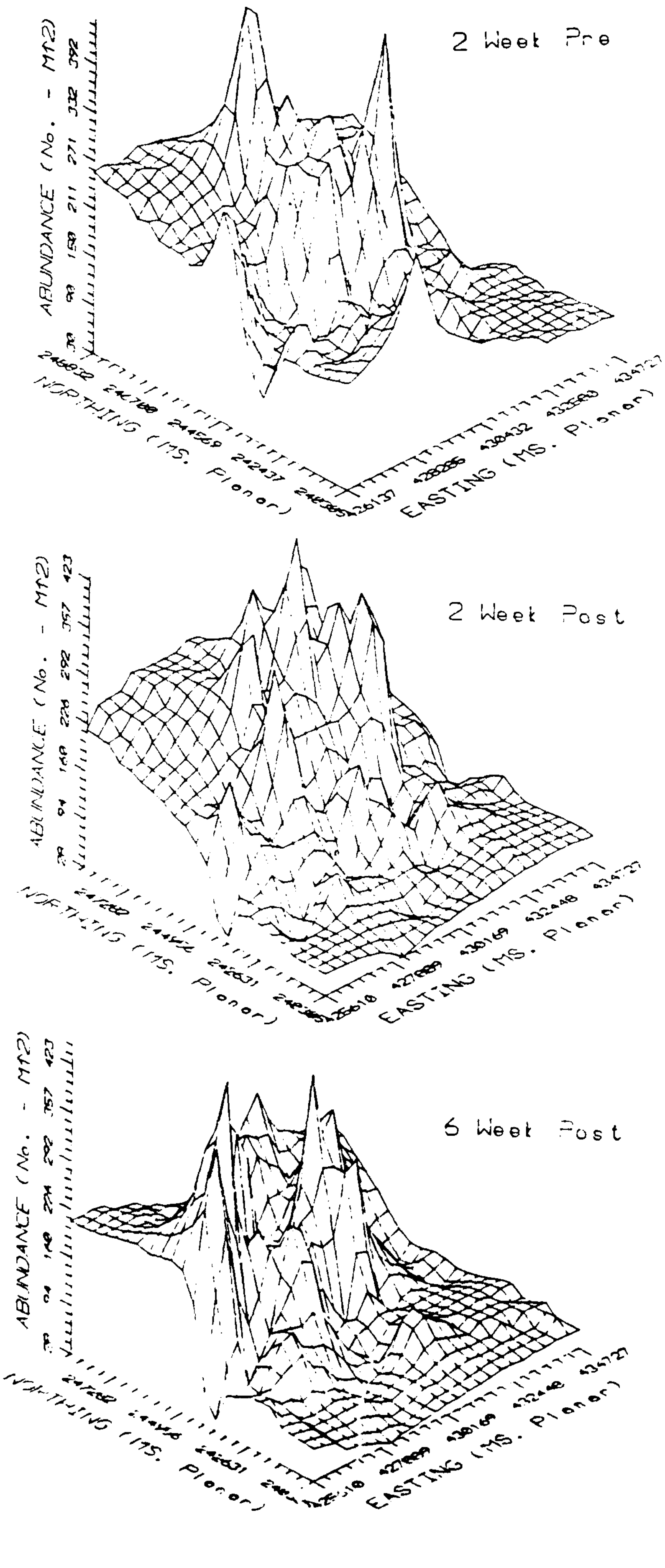


FIGURE 3.2-8.
LEVIFUSCINA (F
AT THE GULFPC

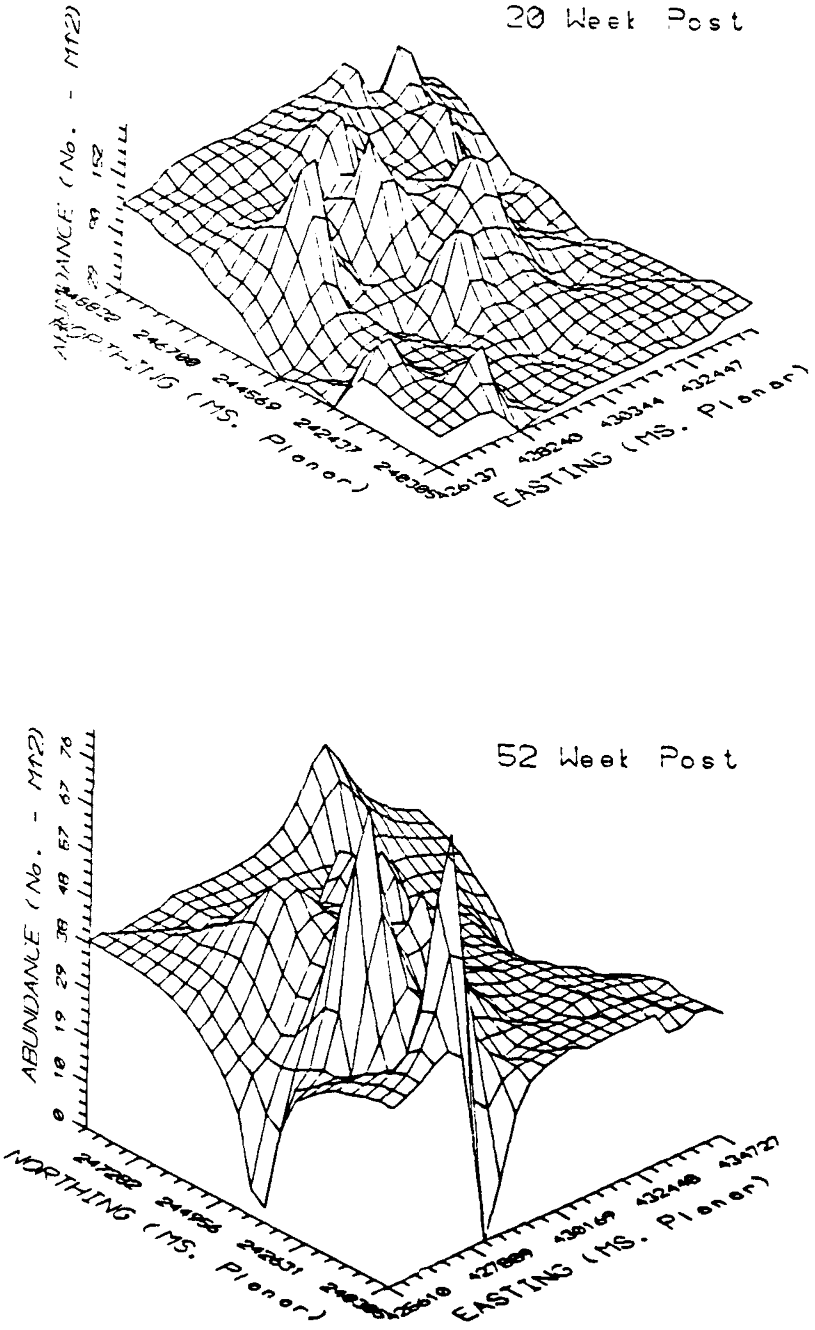


FIGURE 3.2-8. ABUNDANCE OF PODARKEOPSIS LEVIFUSCINA (POLYCHAETA : HESIONIDAE) AT THE GULFPORT HARBOR FIXED STATIONS.

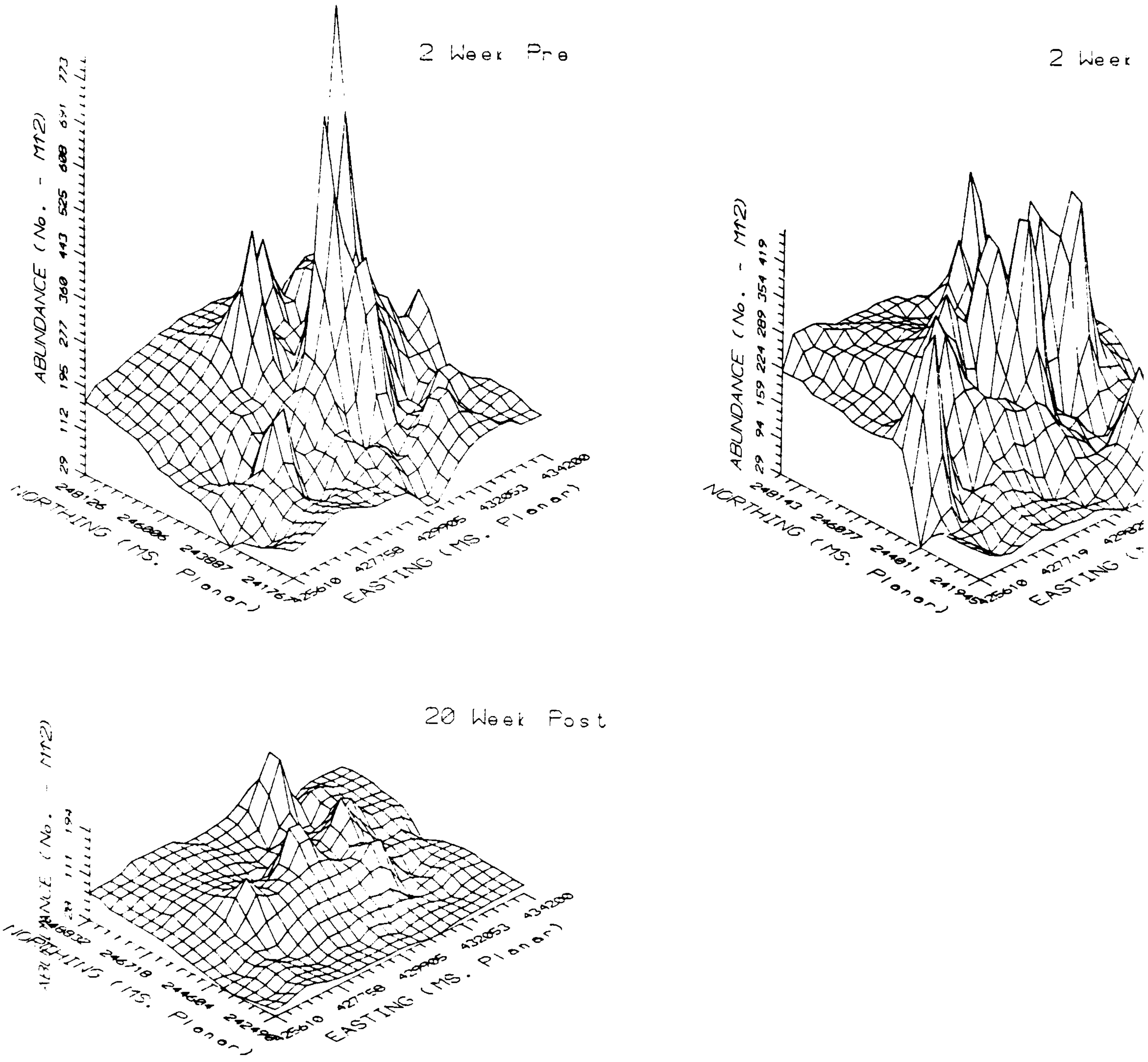


FIGURE 3.2-9.
AURANTIACUS
AT THE GULFP

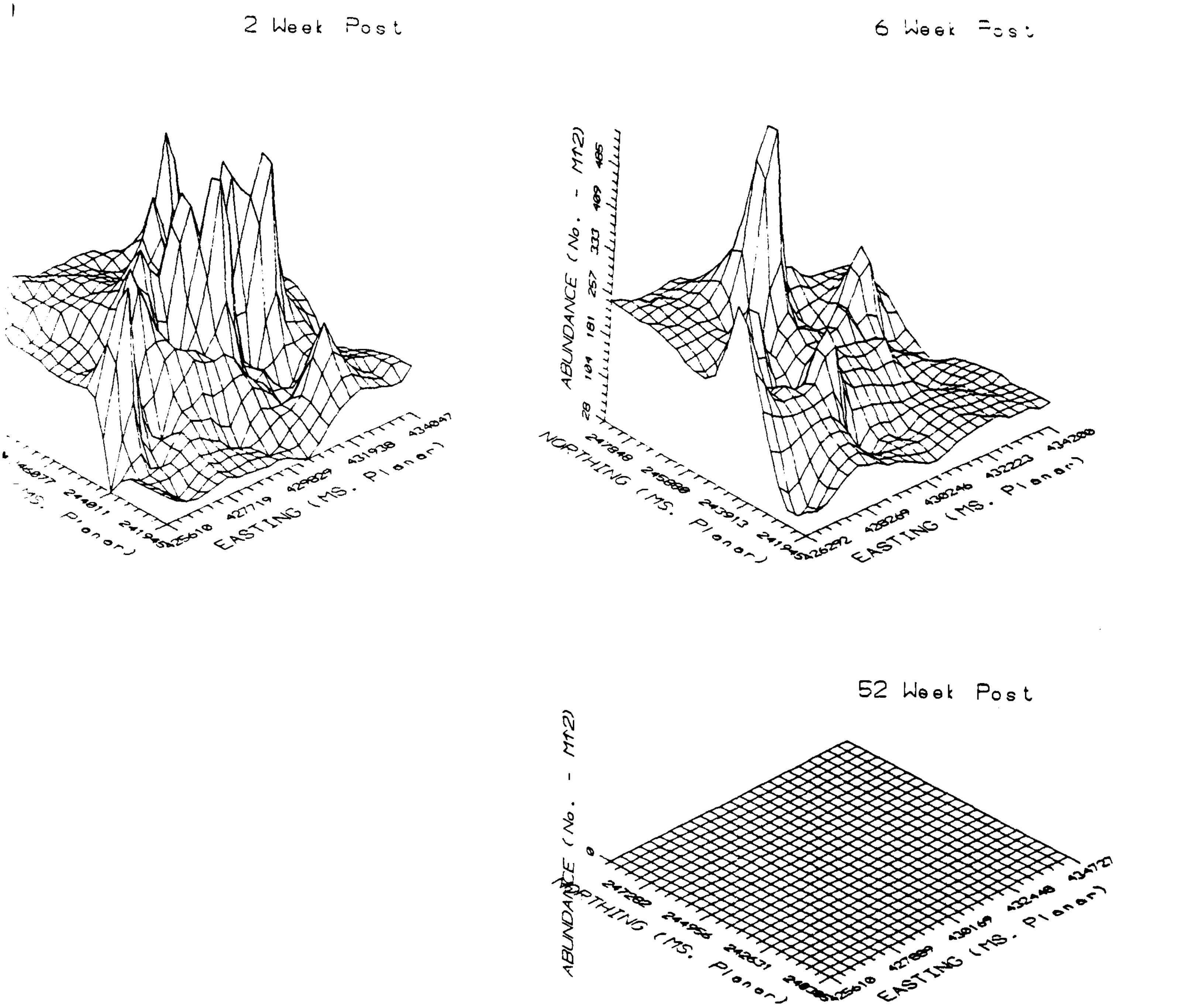


FIGURE 3.2-9. ABUNDANCE OF BALANOGLOSSUS AURANTIACUS (HEMICHORDATA: PTYCHODERIDAE) AT THE GULFPORT HARBOR FIXED STATIONS.

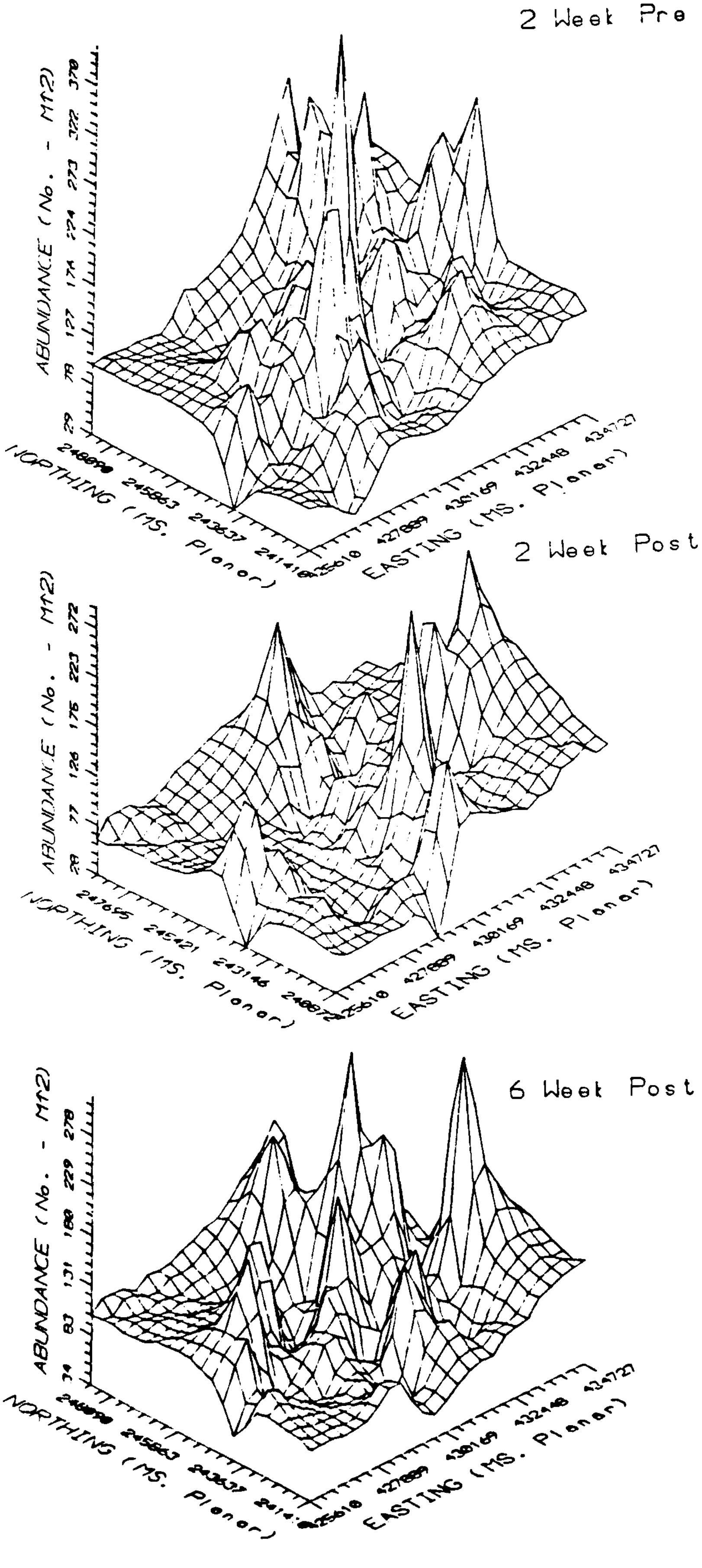


**FIGURE 3.2-10 ABU
ATRA (OPHIUROIDA:
HARBOR FIXED STAT**

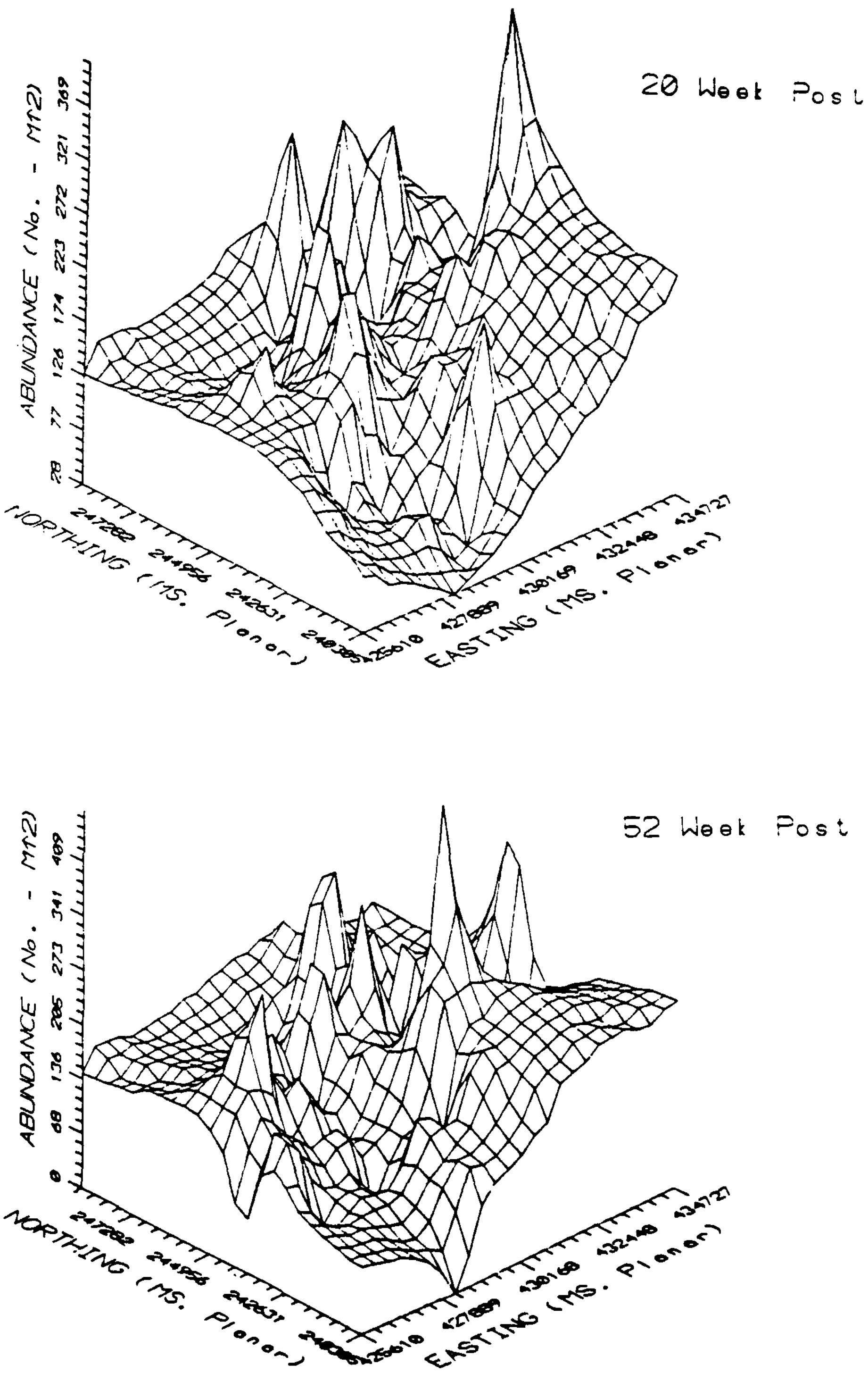


FIGURE 3.2–10 ABUNDANCE OF MICROPHIOPHOLIS ATRA (OPHIUROIDA: OPHIURIDAE) AT THE GULFPORT HARBOR FIXED STATIONS.

Table 3.2-2. ANOVA tables for the major taxa, Gulfport Harbor Study

	SOURCE	F	TAIL PROB.	SIGNIFICANCE
Armandia maculata	MEAN	180.72	0.0000	***
	PERIOD	32.98	0.0000	***
	STATION	3.97	0.0037	**
	PS	1.29	0.2000	
Sigambra tentaculata	MEAN	125.53	0.0000	***
	PERIOD	5.84	0.0002	***
	STATION	0.27	0.8961	
	PS	0.57	0.9060	
Podarkeopsis levifuscina	MEAN	342.26	0.0000	***
	PERIOD	23.14	0.0000	***
	STATION	10.71	0.0000	***
	PS	1.34	0.1748	
Balanoglossus c.f. aurantiacus	MEAN	129.73	0.0000	***
	PERIOD	12.53	0.0000	***
	STATION	7.64	0.0000	***
	PS	1.87	0.0234	
Microphiopholis atra	MEAN	387.01	0.0000	***
	PERIOD	3.74	0.0121	
	STATION	3.31	0.0119	
	PS	0.74	0.7073	
Rhynchocoela	MEAN	925.17	0.0000	***
	PERIOD	77.51	0.0000	***
	STATION	1.88	0.1137	
	PS	2.21	0.0054	**

Error Degrees of Freedom = 275 for all species (n=300).

*** = very highly significant difference
** = highly significant difference

decreasing trend over time is also noted for this species which was not present during the 52-week post-disposal survey, another indication of an annual hydrographic induced community change. ANOVA showed significant spatial and temporal differences for this species as well. Significantly reduced numbers were noted during pre-disposal and 2-week post-disposal periods at the disposal stations and at the disposal, fringe and northeastern reference areas 6-weeks post-disposal. Based on the ANOVA observations above and the spatial variability noted with this species, the reduction noted during the 6-weeks post-disposal is most probably due to a a seasonal event rather than an operational one.

The brittle star, Microphiopholis atra was also quite variable but showed a definite increase moving east in the study area (Figure 3.2-10). Lowered abundance (significant by ANOVA) during the 2-week post-disposal survey was noted in the vicinity of the disposal area and the southwestern reference area but was not evident in the 6-week and 20-week displays when numbers had increased again. The noticeable decline in abundance of the other major taxa was not evident for this species until the 52-week post-disposal survey when its numbers decreased.

Rhynchocoela were another dominant taxa (with an overall mean of 382 individuals $-m^{-2}$) during the study which showed significant annual changes. Significantly higher abundances for these organisms were found during the 52-week post-disposal survey. No significant spatial trends were detectable by ANOVA indicating no impact due to dredged material disposal.

Results of the analyses on total macroinfauna abundance showed (fixed stations) highly significant differences both temporally and spatially with the lowest mean abundances from the disposal stations on the 2-week post-disposal and 6-week post-disposal sampling periods with values of 1793 organisms $-m^{-2}$ and 1884 organisms $-m^{-2}$ respectively. The other areas showed no statistically significant differences.

Numbers of species for the fixed stations also exhibited significant spatial and temporal differences. The lowest values were from the West reference area during the 20-week post-disposal (14.1 taxa) and from the 2-week post-disposal area (17.0 taxa). As noted earlier, the major trend in number of species was a decrease in number with time over the entire study area.

Cluster analysis

The Q-mode (station) analysis for the 2-week predisposal survey generally showed an east-west division in terms of inter-station similarities (Figure 3.2-11) for instance, a cluster was formed between fixed stations 6-6 through 6-10 and stations 4-10 and 5-10 (OTUS 60,55,59,56,57). This is not surprising since the east-west axis was the greatest distance separating the stations.

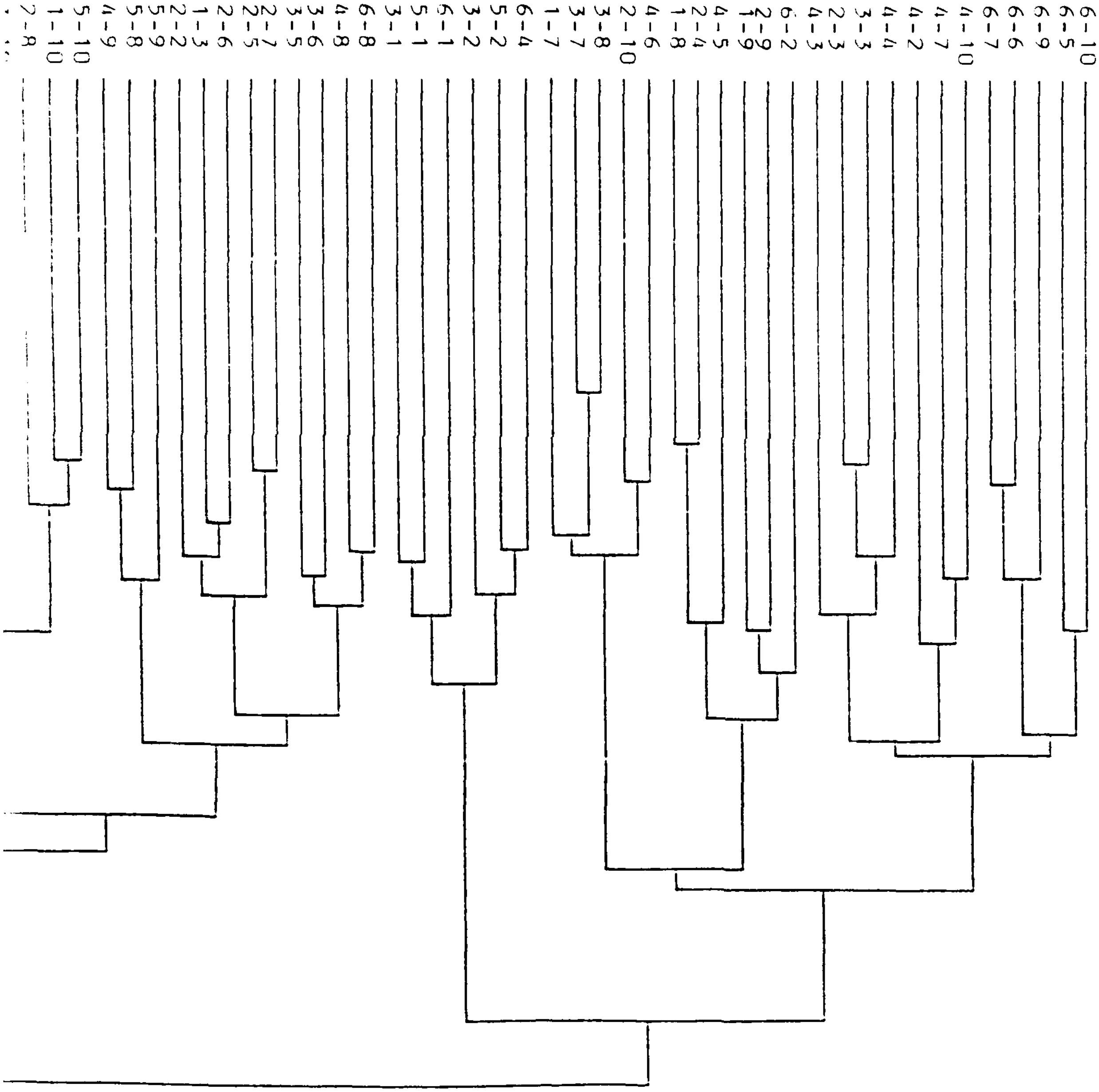
Species (r-mode) analysis for the predisposal sampling (Figure 3.2-12) showed clusters between Microphiopholis atra and Balanoglossus c.f. aurantiacus (OTUS 39 and 8), Armandia maculata, Podarkeopsis levifuscina, and Rhynchocoela (OTUS 6, 59 and 65) and between Sigambra tentaculata, Paraprionospio pinnata, Mediomastus californiensis, and Ogyrides alphaerostris (OTUS 68,56,38 and 49). Generally these were the most abundant species collected during this sampling period.

The Q-mode cluster analysis for the 2-week post-disposal sampling period is presented in Figure 3.2-13. The same East-West polarization was noted in terms of most of the clusters. Of particular note was the clustering of stations 4-3, 4-4, and 5-3 (OTUS 34,35 and 43) all of which are in the impacted portion of the disposal area. This clustering indicates that a community shift occurred in addition to the lowered organisms abundance noted previously.

The same species associations found during the predisposal survey were noted during the 2-week post-disposal sampling period (Figure 3.2-14). No other particular associations of note were found.

The 6-week post-disposal Q-mode analysis had a more randomized nature to the station associations (Figure 3.2-15). Some of the East-West trends remained

Dendrogram Sequence of OTUS



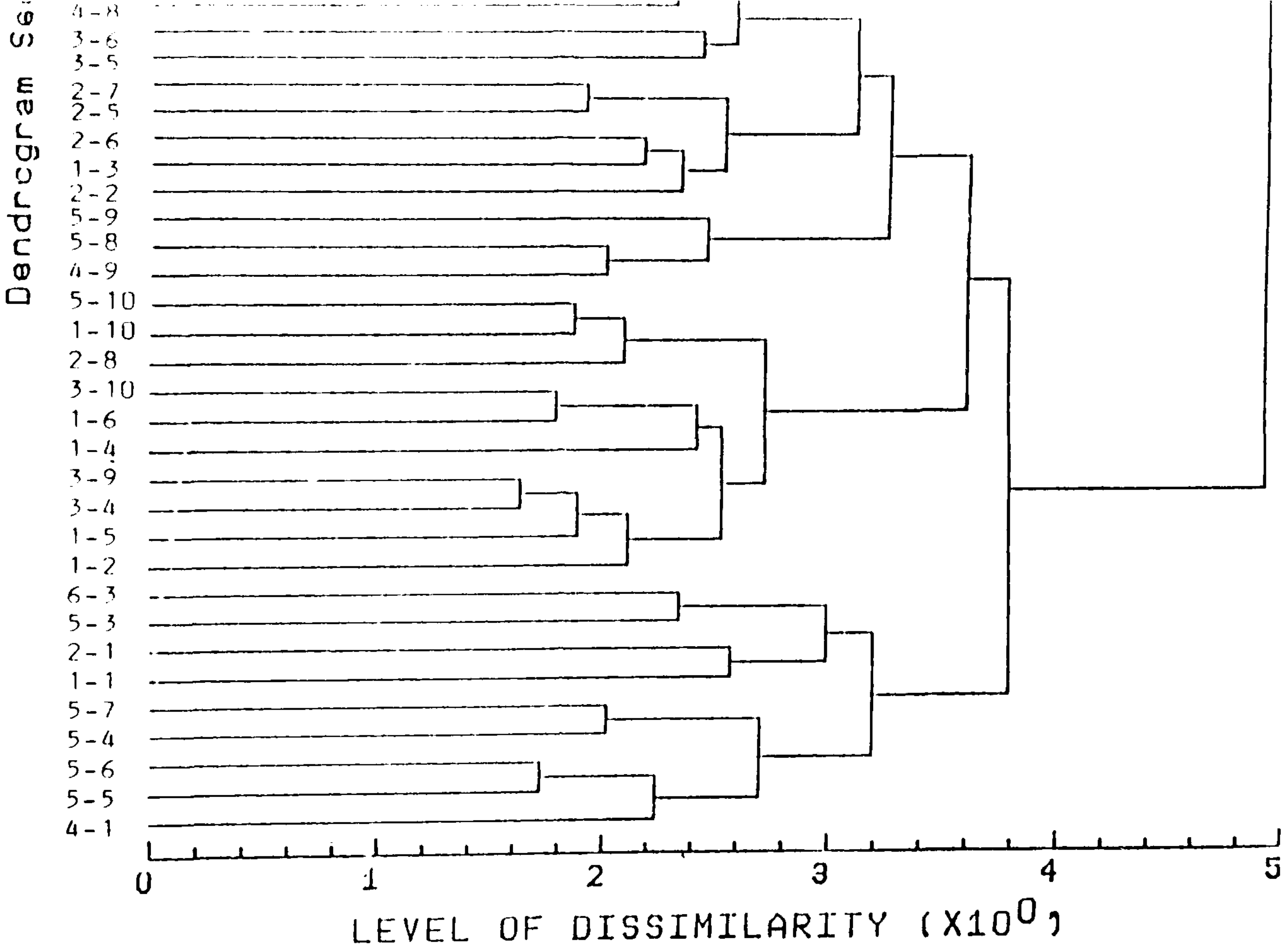
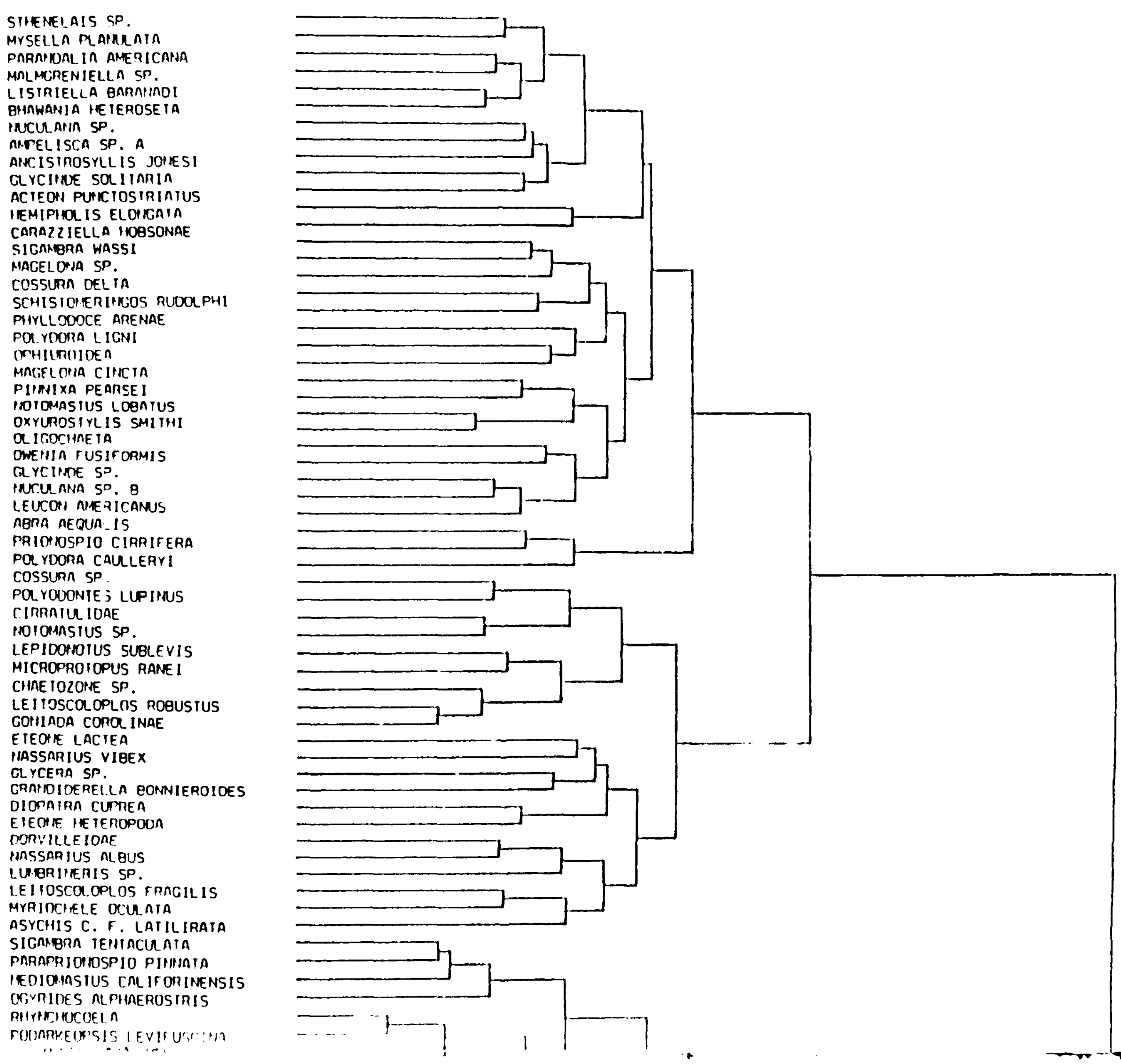


FIGURE 3.2-11 Q-MODE CLUSTER ANALYSIS FOR THE 2-WEEK PRE-DISPOSAL SURVEY.


STHENELAIS SP.
MYSELLA PLANULATA
PARANDALIA AMERICANA
MALMGRENIELLA SP.
LISTRIELLA BARNARDI
BHAWANIA HETEROSETA
NUCULANA SP.
AMPELISCA SP. A
ANCISTROSYLLIS JONESI
GLYCINDE SOLITARIA
ACTEON PUNCTOSTRIATUS
HEMIPHOLIS ELONGATA
CARAZZIELLA HOBSONAE
SIGAMBRA WASSI
MAGELONA SP.
COSSURA DELTA
SCHISTOMERINGOS RUDOLPHI
PHYLLODOCE ARENAE
POLYDORA LIGNI
OPHIUROIDEA
MAGELONA CINCTA
PINNIXA PEARSEI
NOTOMASTUS LOBATUS
OXYUROSTYLIS SMITHI
OLIGOCHAETA
OWENIA FUSIFORMIS
GLYCINDE SP.
NUCULANA SP. B
LEUCON AMERICANUS
ABRA AEQUALIS
PRIONOSPIO CIRRIFERA
POLYDORA CAULLERYI
COSSURA SP.
POLYODONTES LUPINUS
CIRRATULIDAE
NOTOMASTUS SP.
LEPIDONOTUS SUBLEVIS
MICROPROTOPUS RANEI
CHAETOZONE SP.
LEITOSCOLOPLOS ROBUSTUS
GONIADA COROLINAE
ETEONE LACTEA
NASSARIUS VIBEX
GLYCERA SP.
GRANDIDERELLA BONNIEROIDES
DIOPATRA CUPREA
ETEONE HETEROPODA
DORVILLEIDAE
NASSARIUS ALBUS
LUMBRINERIS SP.
LEITOSCOLOPLOS FRAGILIS
MYRIOCHELE OCULATA
ASYCHIS C. F. LATILIRATA
SIGAMBRA TENTACULATA
PARAPRIONOSPIO PINNATA
MEDIOMASTUS CALIFORINENSIS
OGYRIDES ALPHAEROSTRIS
RHYNCHOCOELA
PODARKEOPSIS LEVIFUSCINA

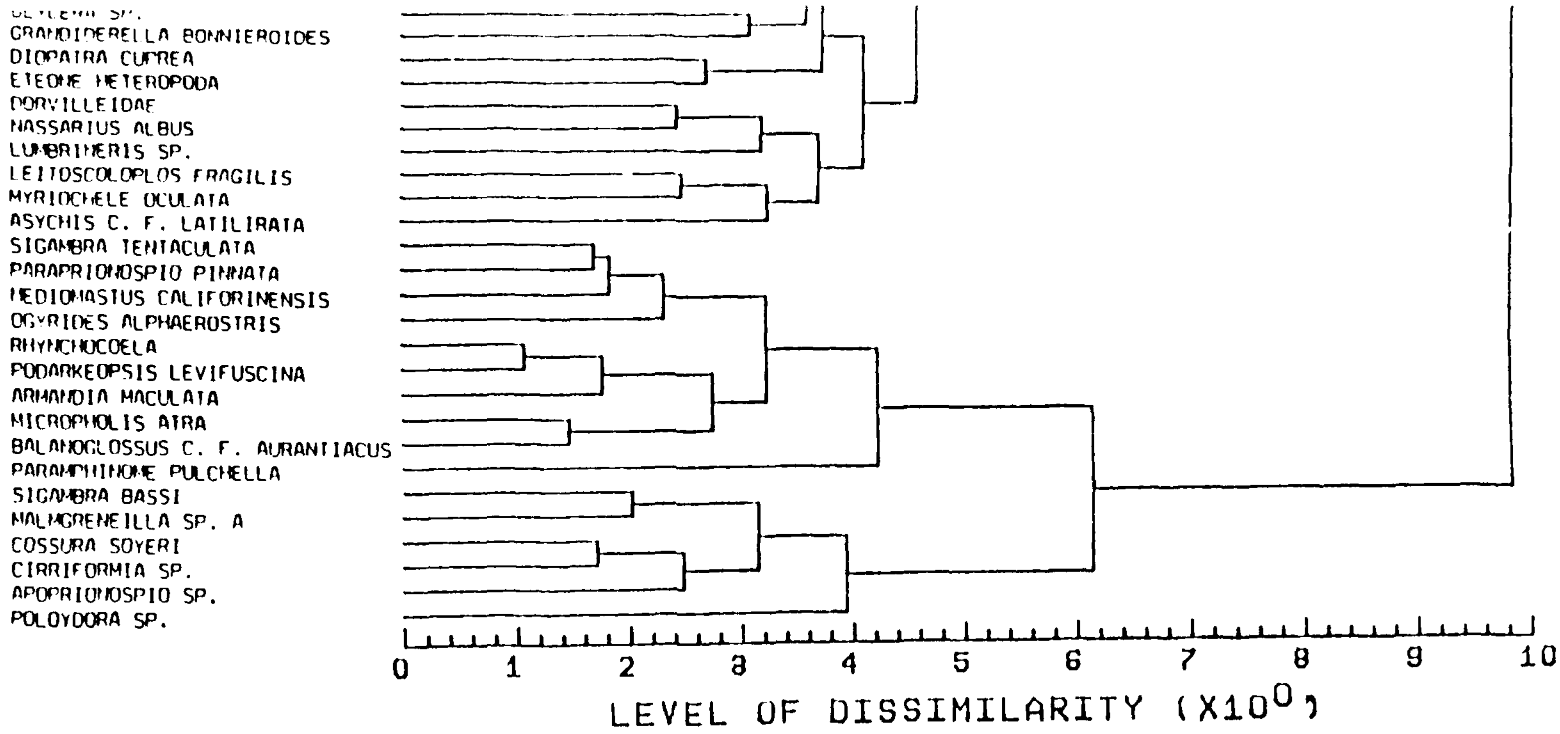
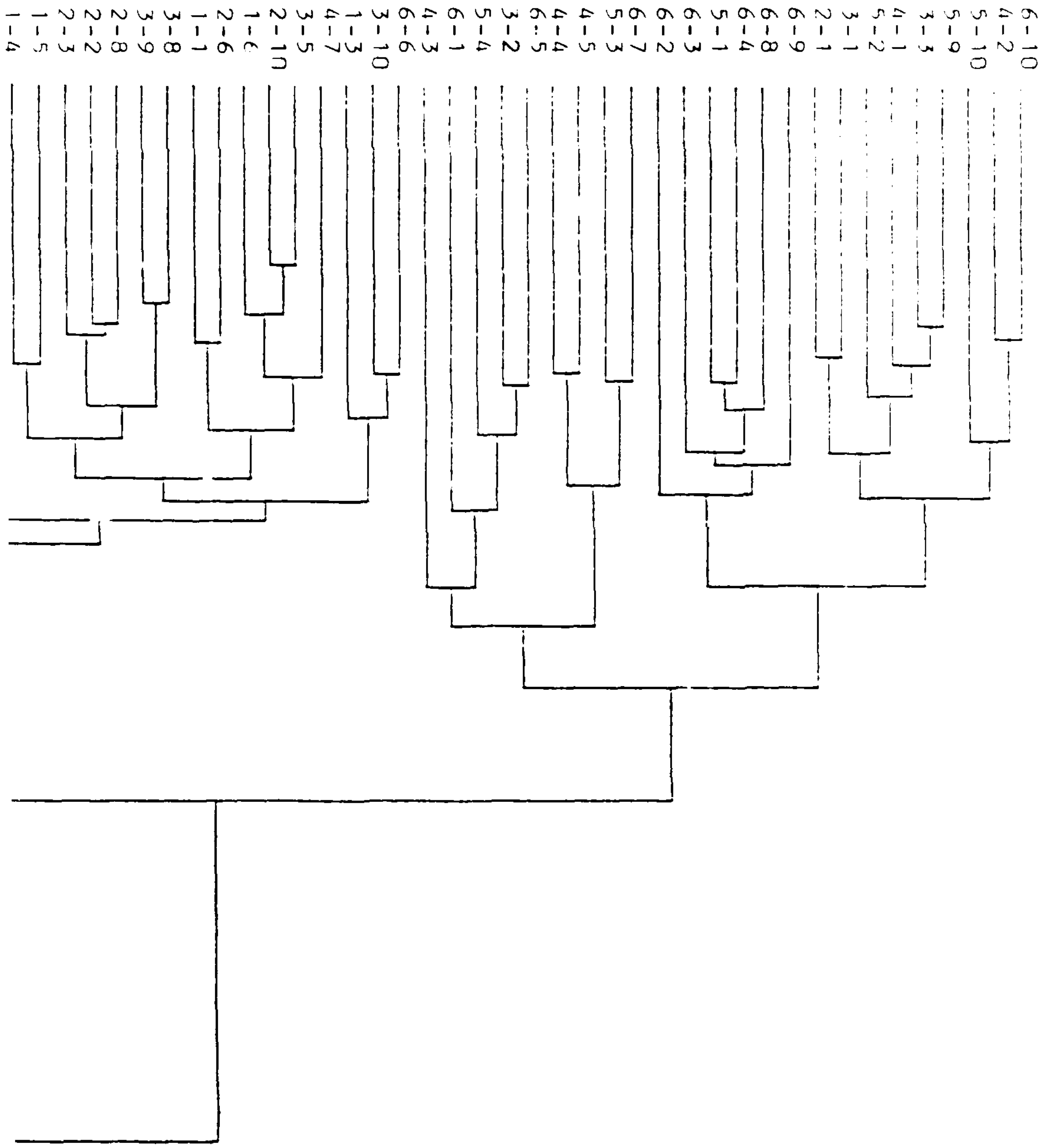


FIGURE 3.2-12. R-MODE CLUSTER ANALYSIS FOR THE 2-WEEK PRE-DISPOSAL SURVEY.

ndrogram Sequence of CTUS



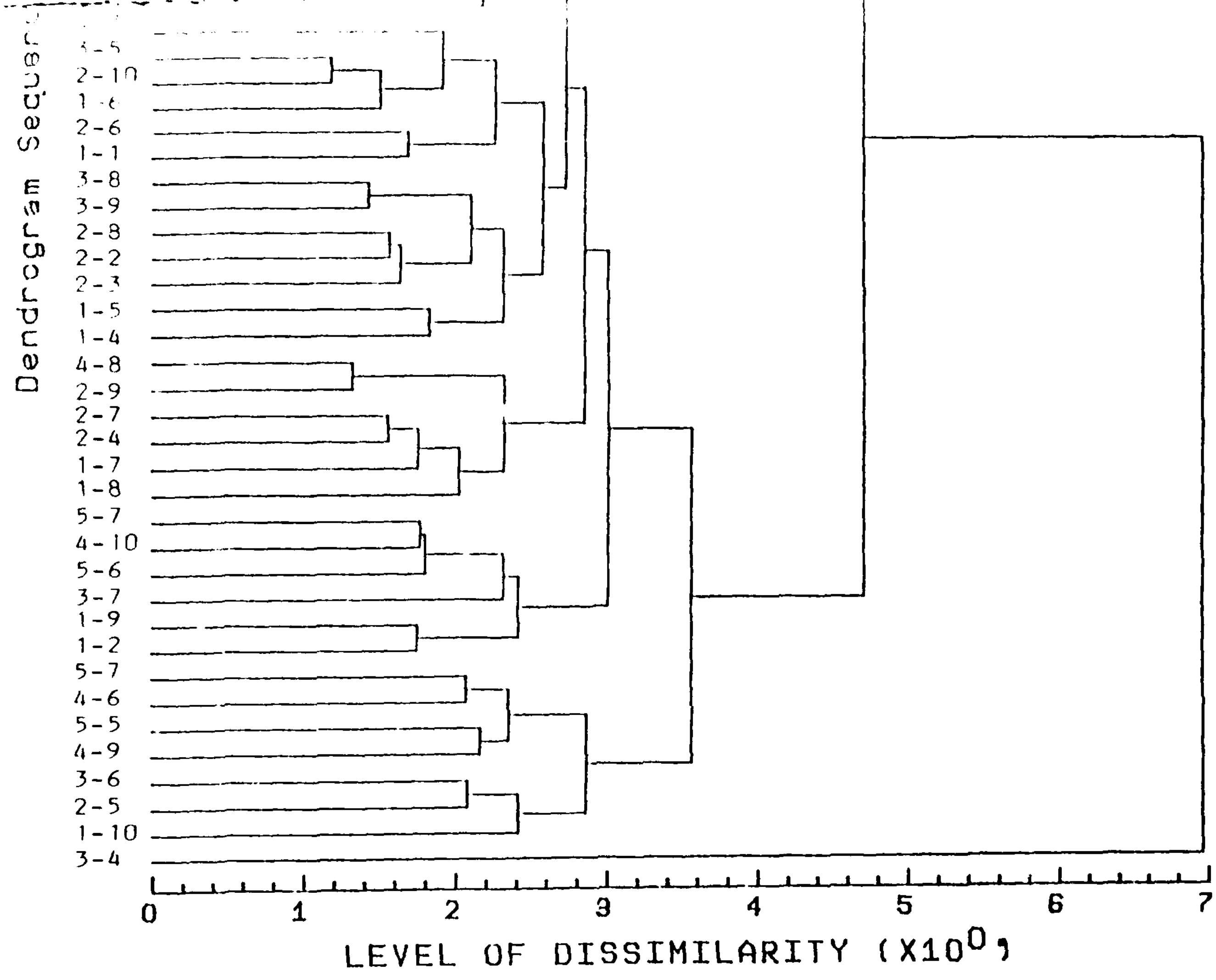
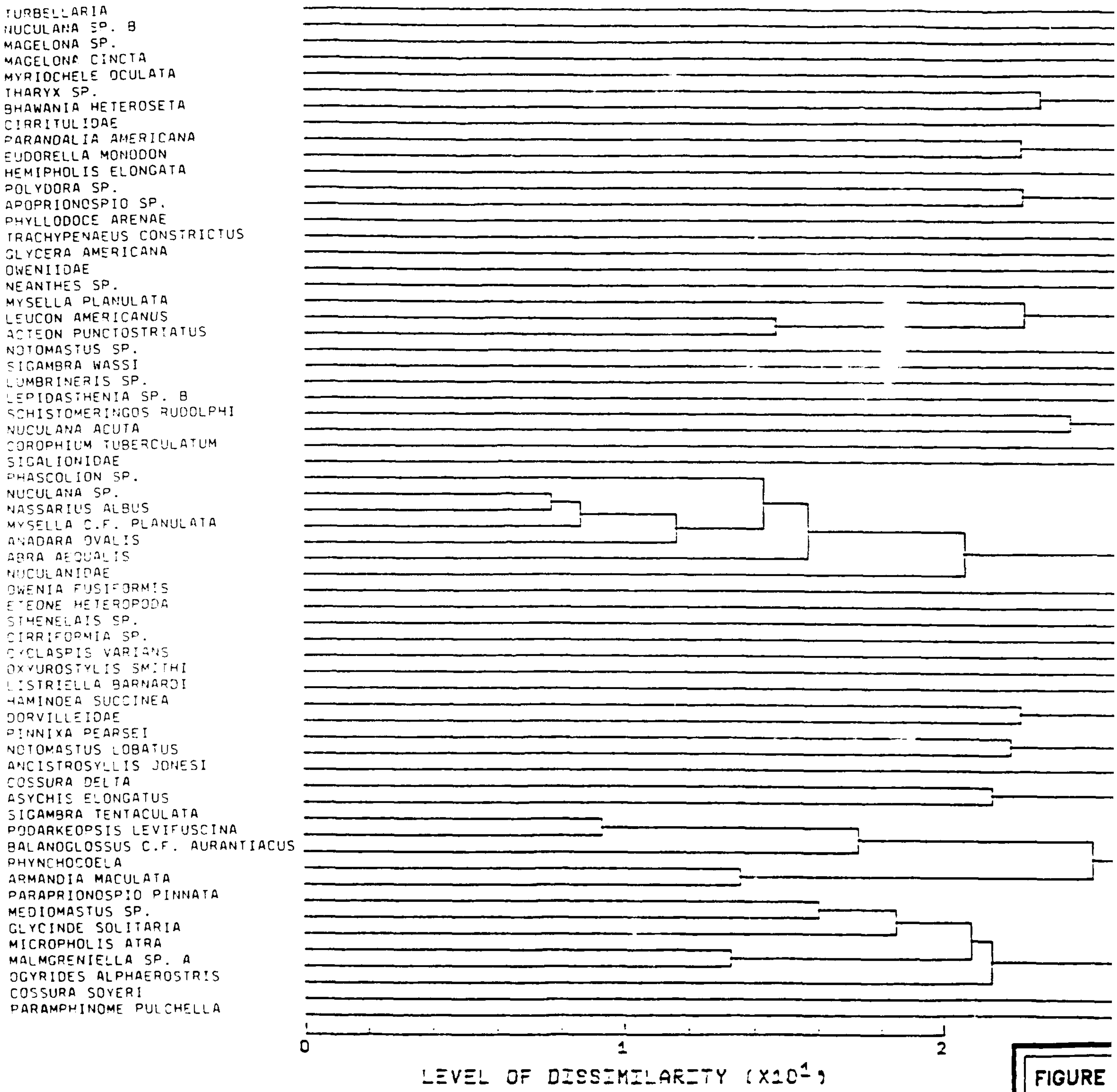


FIGURE 3.2-13. Q-MODE CLUSTER ANALYSIS FOR THE 2-WEEK POST-DISPOSAL SURVEY.



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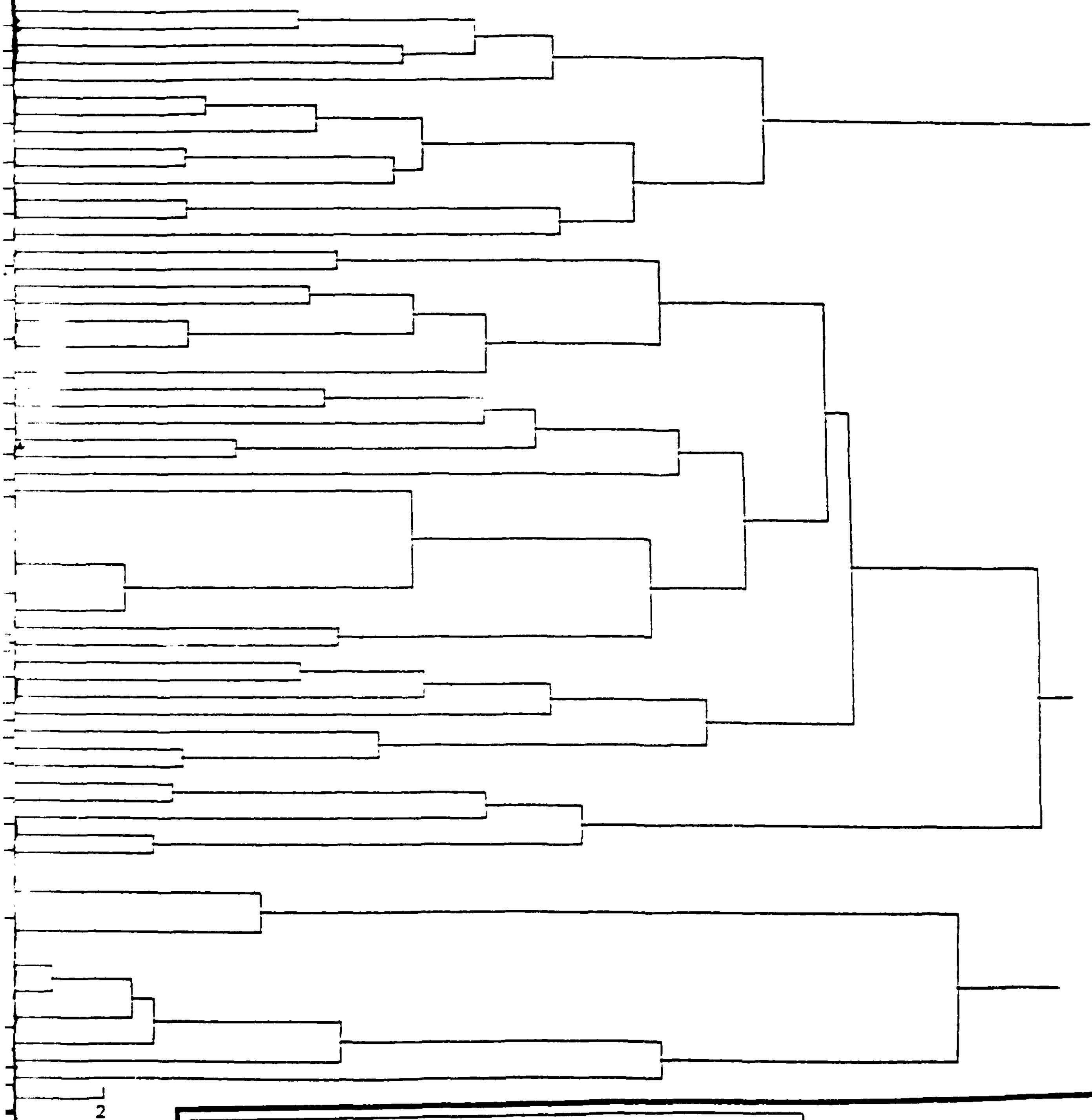
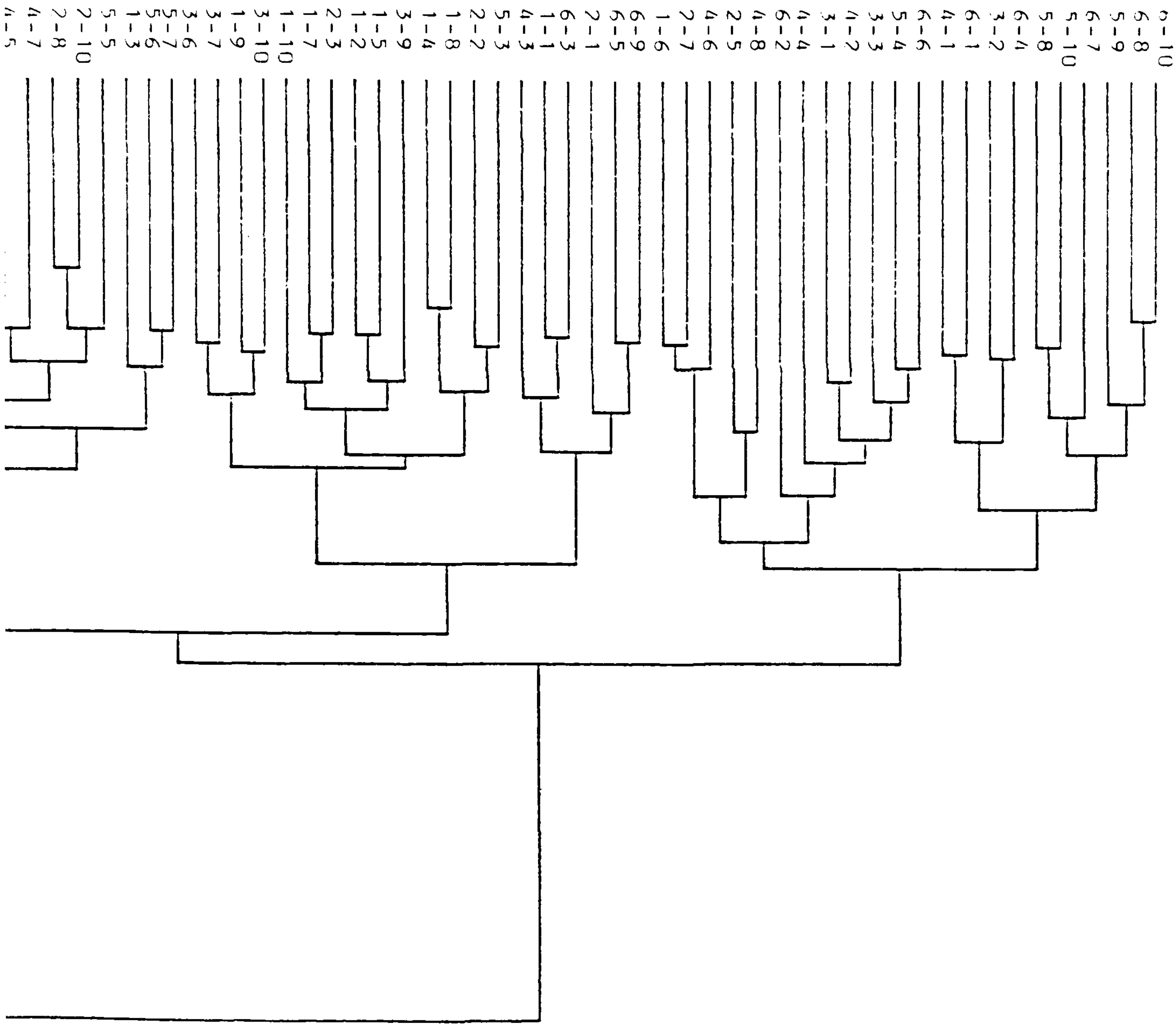


FIGURE 3.2-14. R-MODE CLUSTER ANALYSIS FOR THE 2-WEEK POST-DISPOSAL SURVEY.

Dendrogram Sequence of OTUS



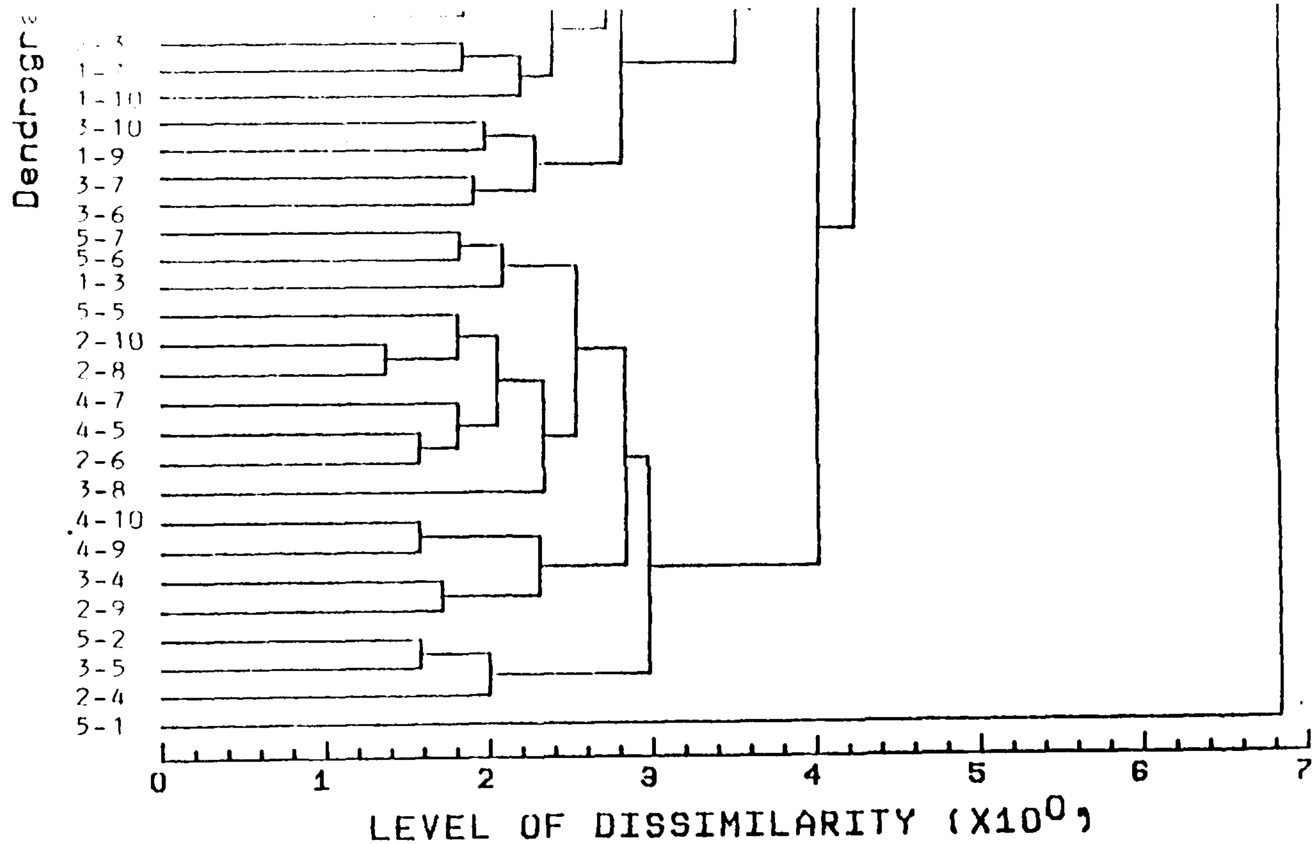


FIGURE 3.2-15. Q-MODE CLUSTER ANALYSIS FOR THE 6-WEEK POST-DISPOSAL SURVEY.

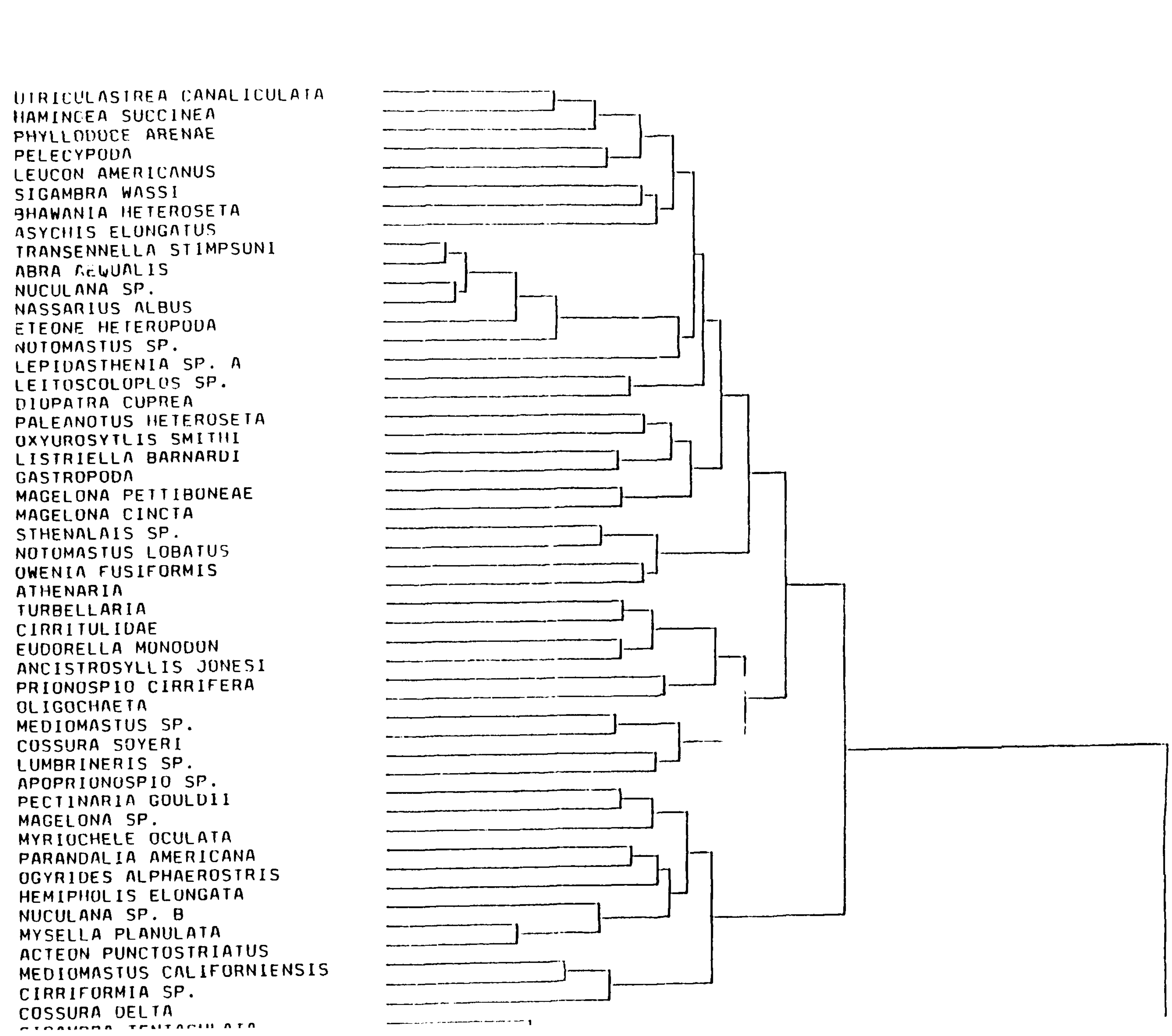
but were less distinct. The stations noted in the 2-week post disposal survey as being closely associated in a single cluster, stations 4-3, 4-4 and 5-3 (OTUS 34,35 and 43) were found in entirely separate clusters during this sampling. Generally the species (r-mode) associations during this survey remained the same (Figure 3.2-16).

The 20-week post-disposal survey Q-mode analysis was similar to the 6-week analysis in that no clear pattern across stations were noted (Figure 3.2-17). The same species clusters (Figure 3.2-18) were also noted except that Armandia, which was a dominant in the previous samplings, was no longer associated with its former species group. It is assumed that low abundance during the month of May contributed to its movement to another group.

The 52-week Q mode analysis resulted in two major groupings that spanned the entire study, testifying to the homogeneity of the environment (Figure 3.2-19). For example, station 6-10 (extreme southeast corner) and stations 2-2 and 1-3 (northwest corner) are clustered together. A similar situation was noted for the southwest and northeastern corners. The disposal stations were also distributed among several groups and did not show an consistent pattern. The closest association in the r-mode analysis (Figure 3.2-20) was between the taxa Microphiopholis atra, Paraprionospio pinnata, Mediomastus ambiseta, rhynchocoela and Cyclaspis c.f. varians which consisted of the most common species during this sampling period.

Random Stations

Data on the macroinfauna collected from the random stations are presented in Appendix C (Part I). They provide information relative to the adequacy of sampling for the fixed stations and represent a pool of data that is generally more usable from a statistical viewpoint, primarily because of the amount of replication. In other words, the data from this aspect of the sampling are designed to provide a body of information that can withstand the rigors of analytical statistical scrutiny. On the other hand they represent information on a more limited area spatially, and for that reason may have another bias. In any case, inclusion of both fixed and random stations provides the opportunity to see the weakness and strength of both sampling methods in detecting biological changes.


UTRICULASTREA CANALICULATA
HAMINCEA SUCCINEA
PHYLLODOCE ARENAE
PELECYPODA
LEUCON AMERICANUS
SIGAMBRA WASSI
BHAWANIA HETEROSETA
ASYCHIS ELONGATUS
TRANSENNELLA STIMPSONI
ABRA AEQUALIS
NUCULANA SP.
NASSARIUS ALBUS
ETEONE HETEROPODA
NOTOMASTUS SP.
LEPIDASTHENIA SP. A
LEITOSCOLOPLOS SP.
DIOPATRA CUPREA
PALEANOTUS HETEROSETA
OXYUROSYTLIS SMITHI
LISTRIELLA BARNARDI
GASTROPODA
MAGELONA PETTIBONEAE
MAGELONA CINCTA
STHENALAIS SP.
NOTOMASTUS LOBATUS
OWENIA FUSIFORMIS
ATHENARIA
TURBELLARIA
CIRRITULIDAE
EUDORELLA MONODON
ANCISTROSYLLIS JONESI
PRIONOSPIO CIRRIFERA
OLIGOCHAETA
MEDIOMASTUS SP.
COSSURA SOYERI
LUMBRINERIS SP.
APOPRIONOSPIO SP.
PECTINARIA GOULDII
MAGELONA SP.
MYRIOCHELE OCULATA
PARANDALIA AMERICANA
OGYRIDES ALPHAEROSTRIS
HEMIPHOLIS ELONGATA
NUCULANA SP. B
MYSELLA PLANULATA
ACTEON PUNCTOSTRIATUS
MEDIOMASTUS CALIFORNIENSIS
CIRRIFORMIA SP.
COSSURA DELTA

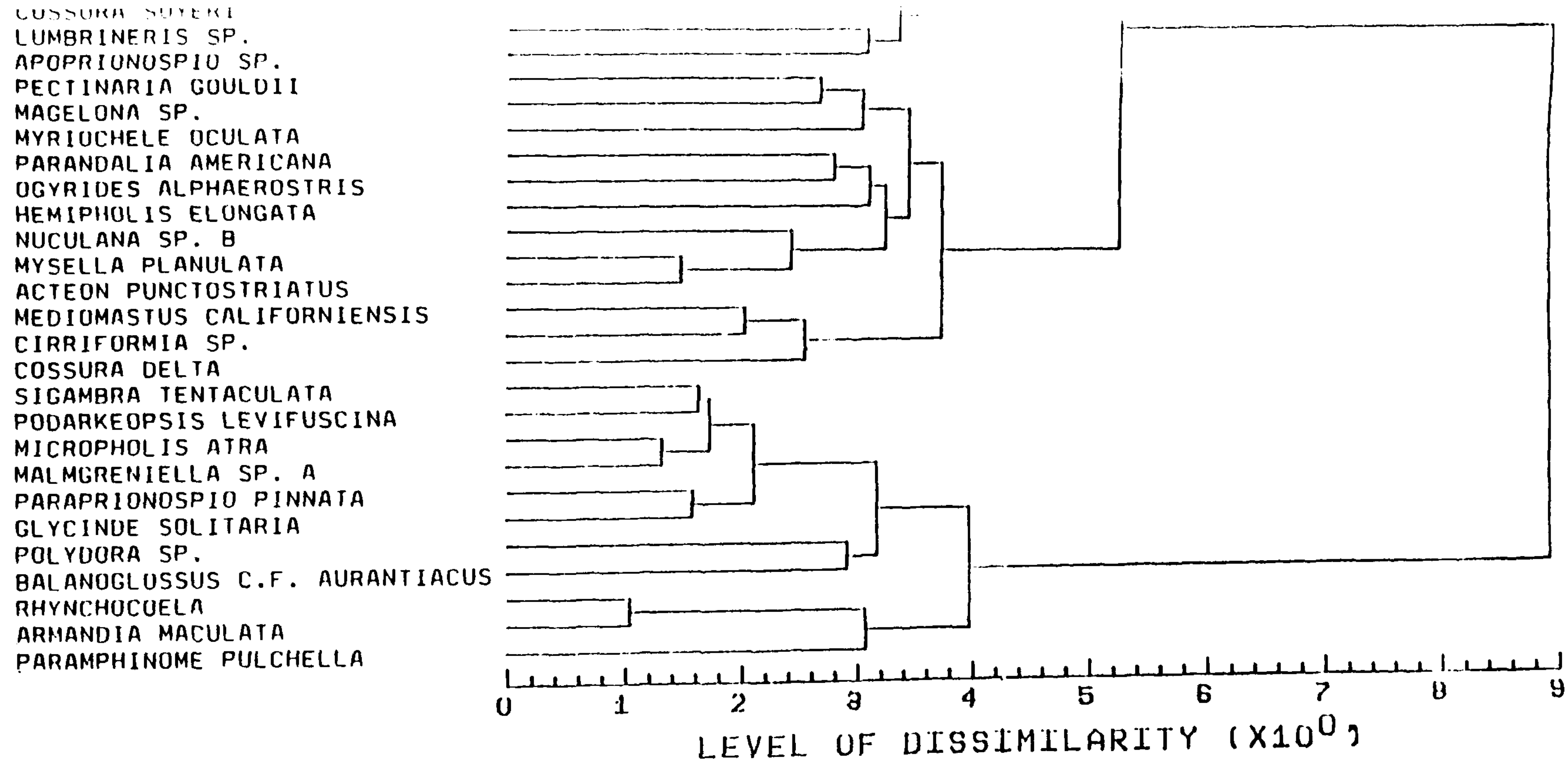
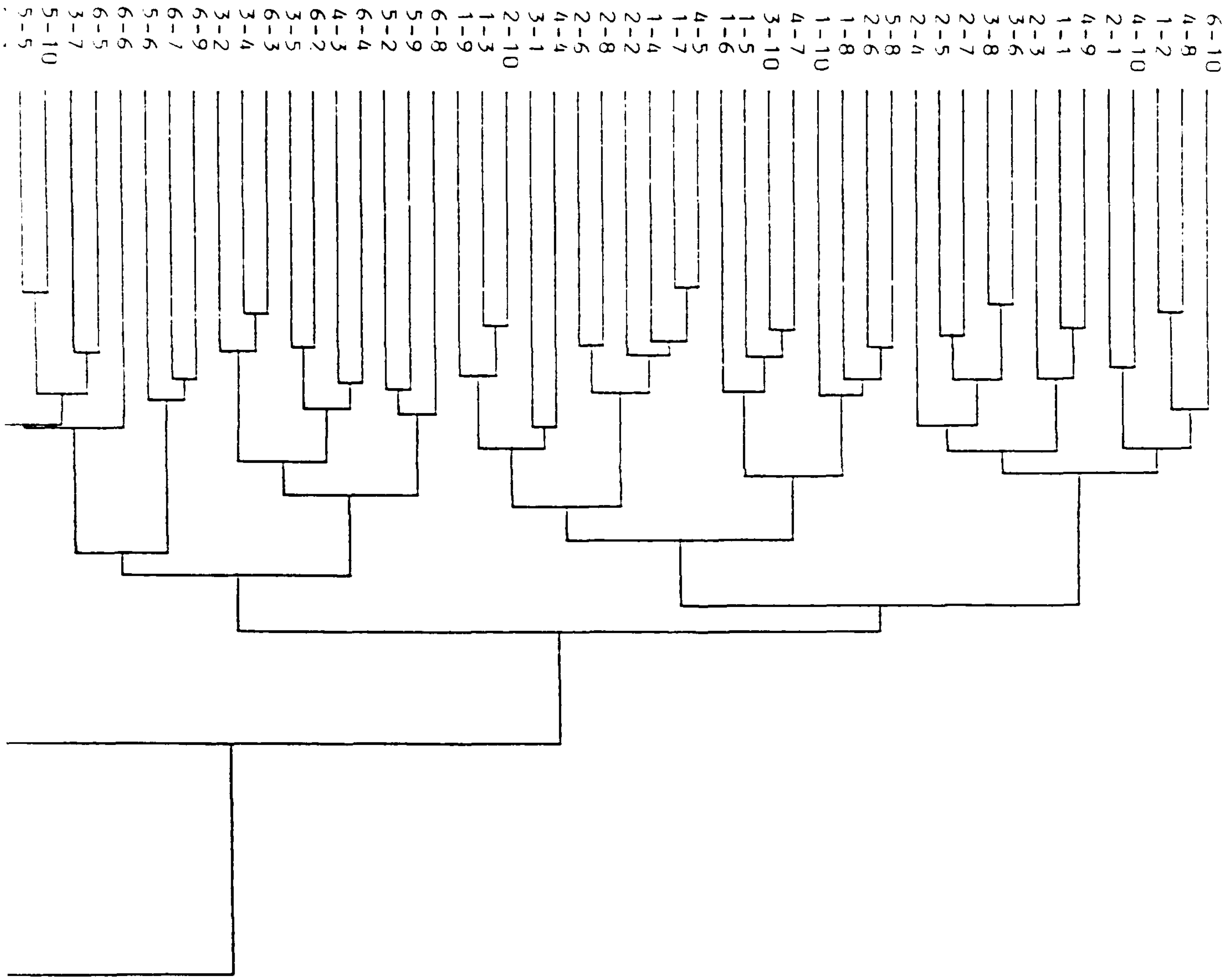


FIGURE 3.2-16. R-MODE CLUSTER ANALYSIS FOR THE 6-WEEK POST-DISPOSAL SURVEY.

Dendrogram Sequence of OTUS



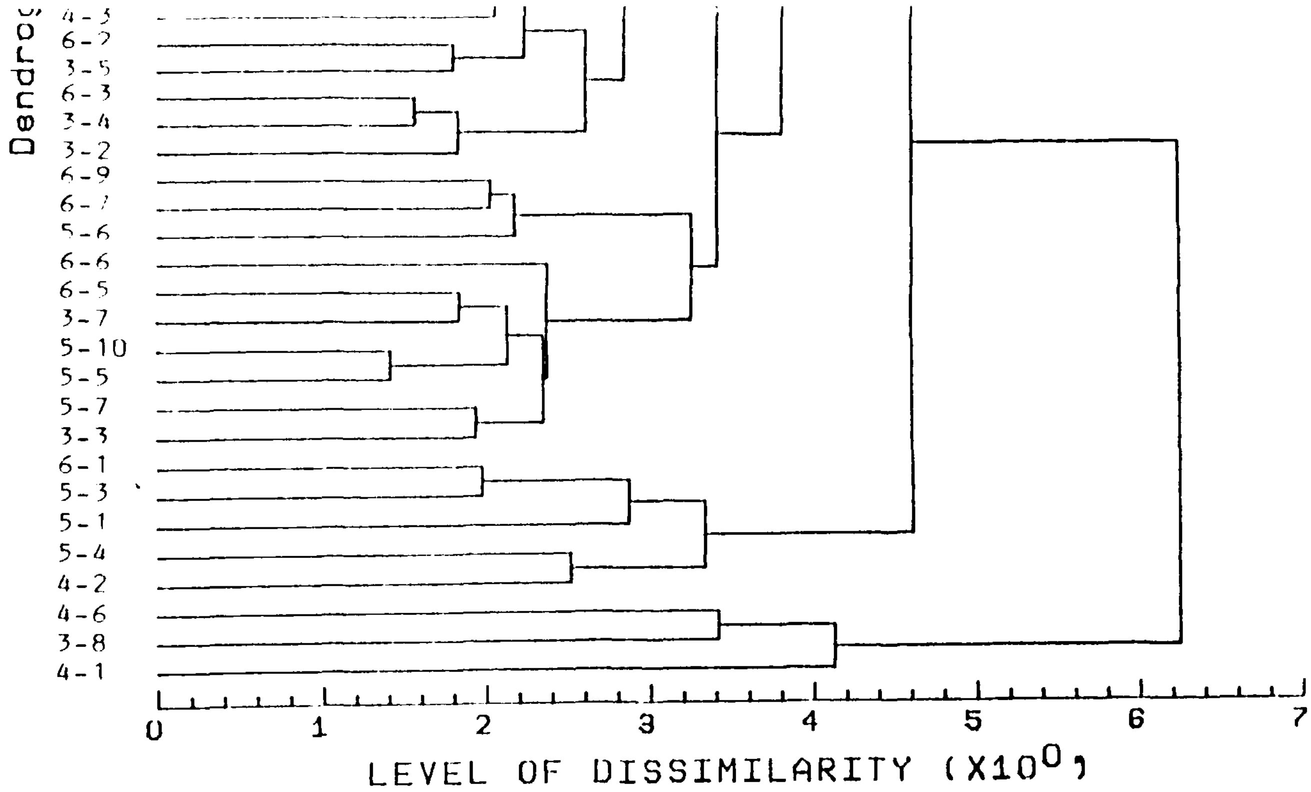


FIGURE 3.2-17. Q-MODE CLUSTER ANALYSIS FOR THE 20-WEEK POST-DISPOSAL SURVEY.

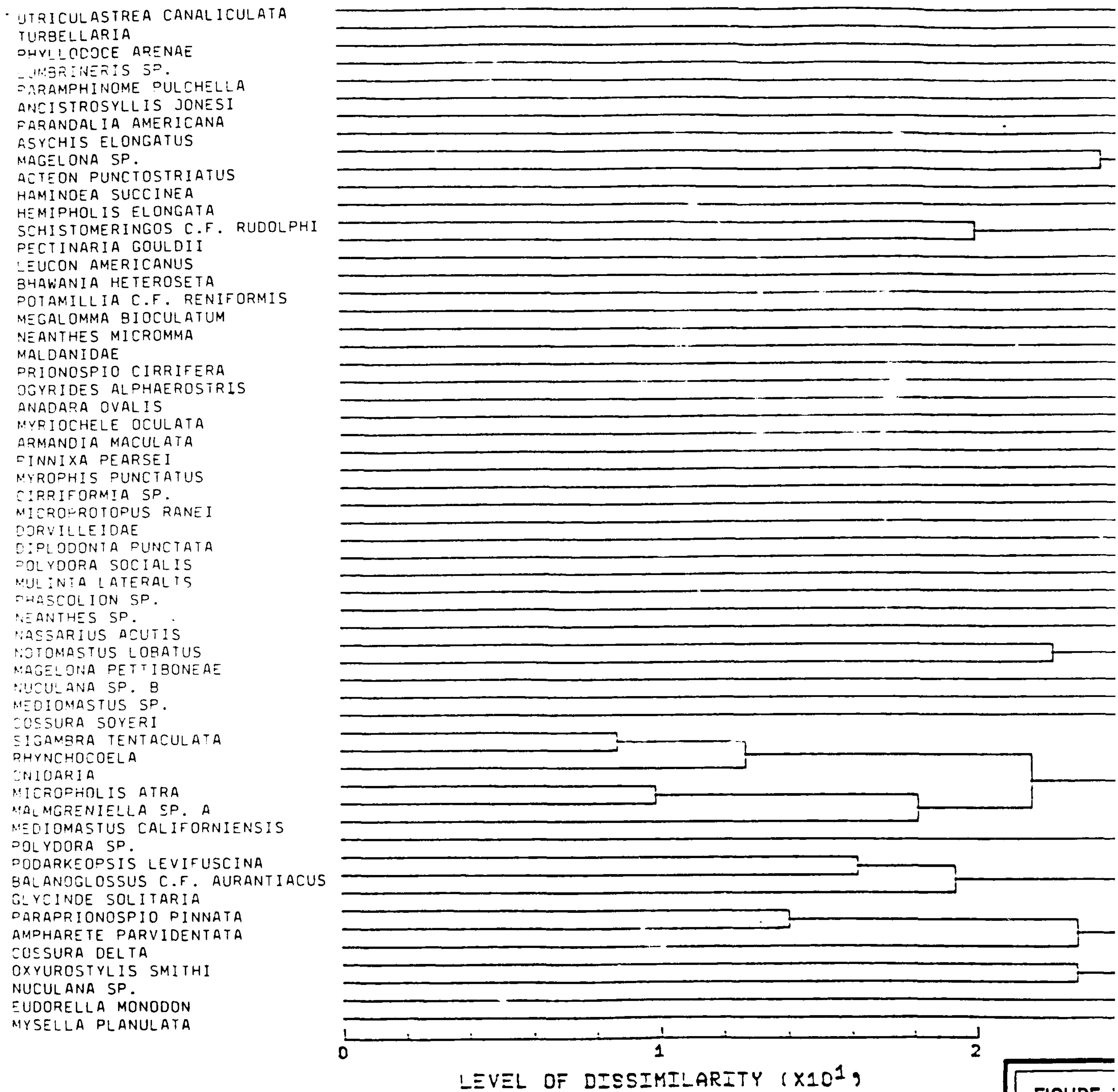


FIGURE :
FOR THE

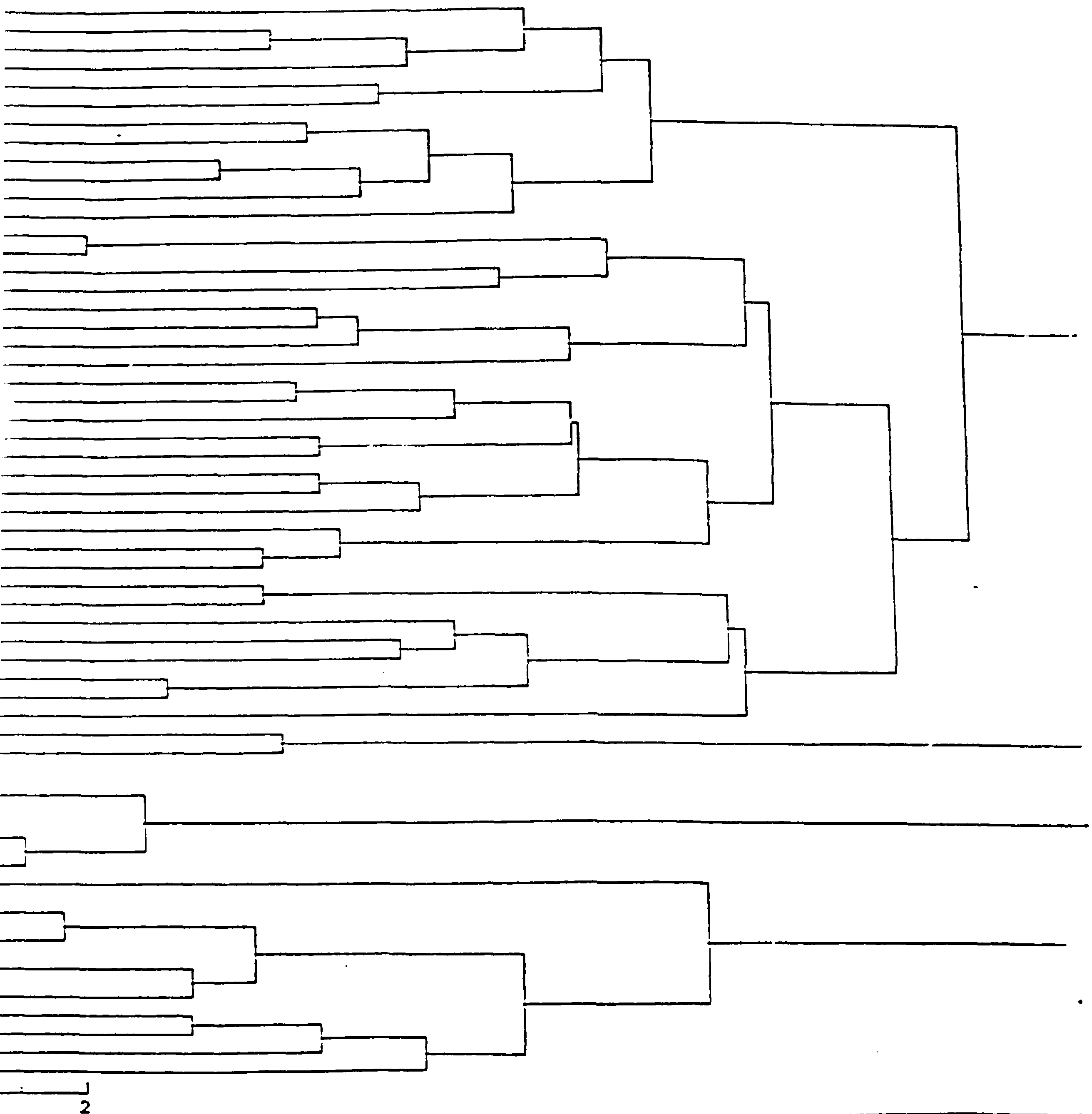
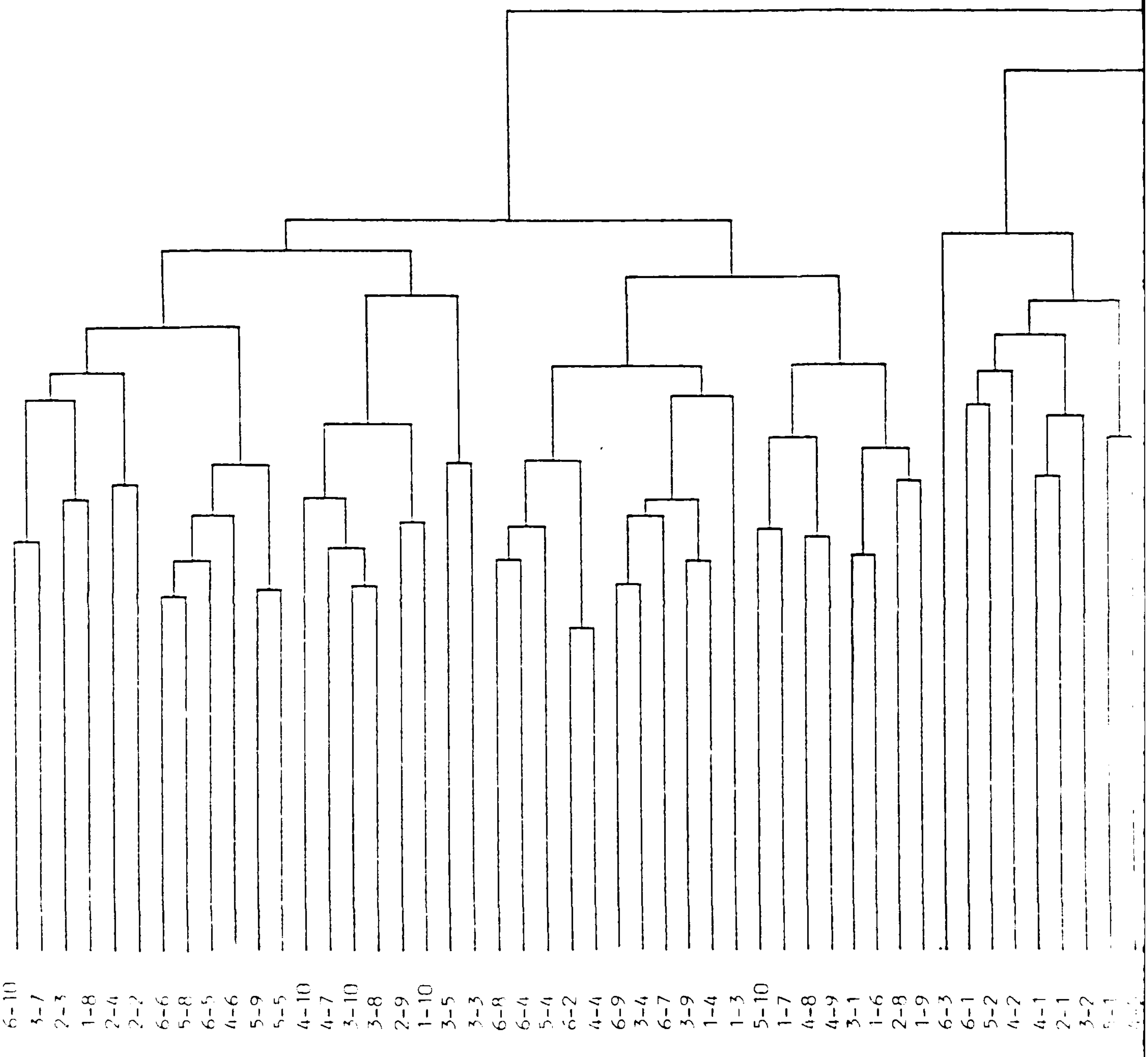


FIGURE 3.2-18. R-MODE CLUSTER ANALYSIS FOR THE 20-WEEK POST-DISPOSAL SURVEY.


6-10
3-7
2-3
1-8
2-4
2-2
6-6
5-8
6-5
4-6
5-9
5-5
4-10
4-7
3-10
3-8
2-9
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4-1
2-1
3-2

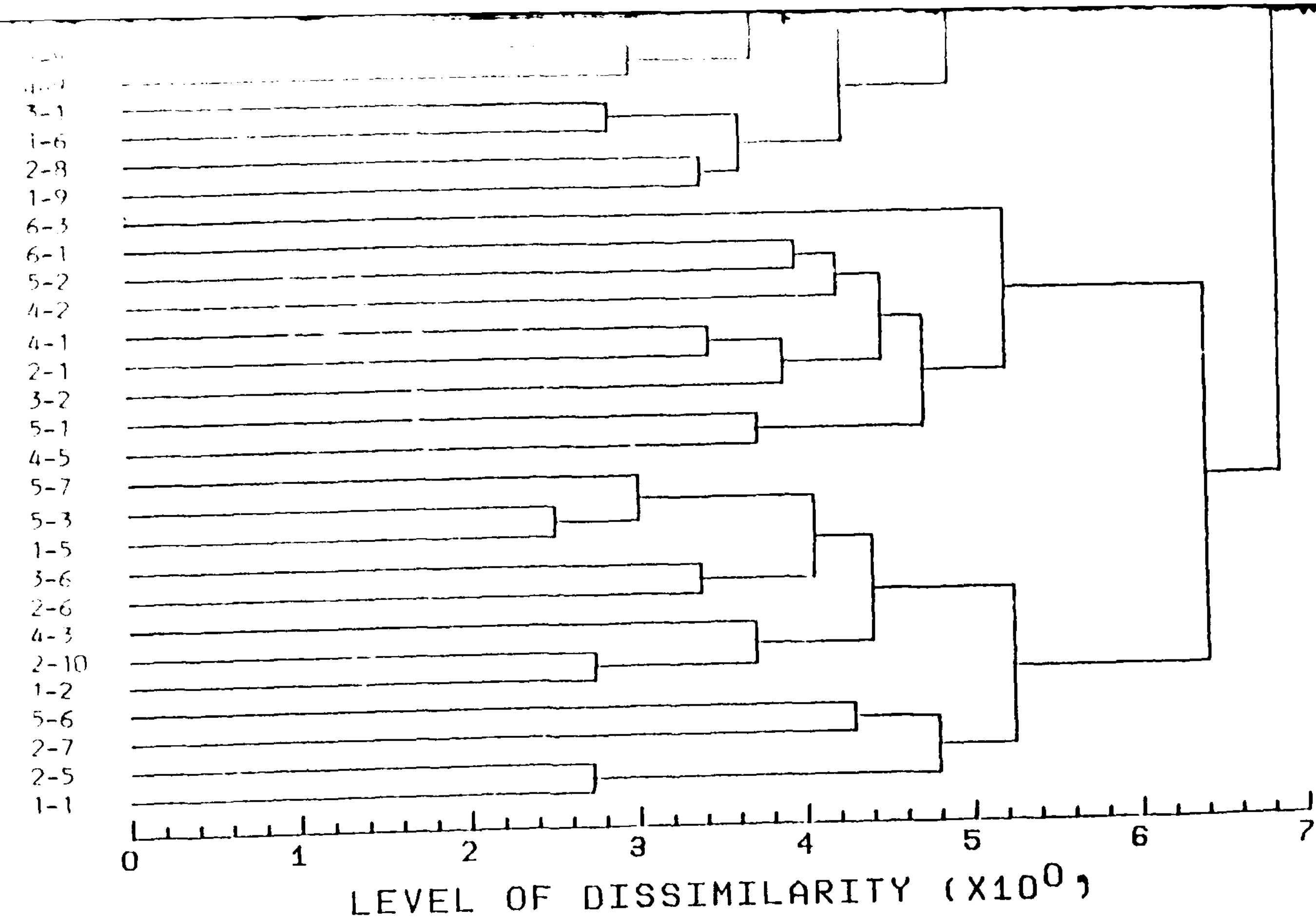
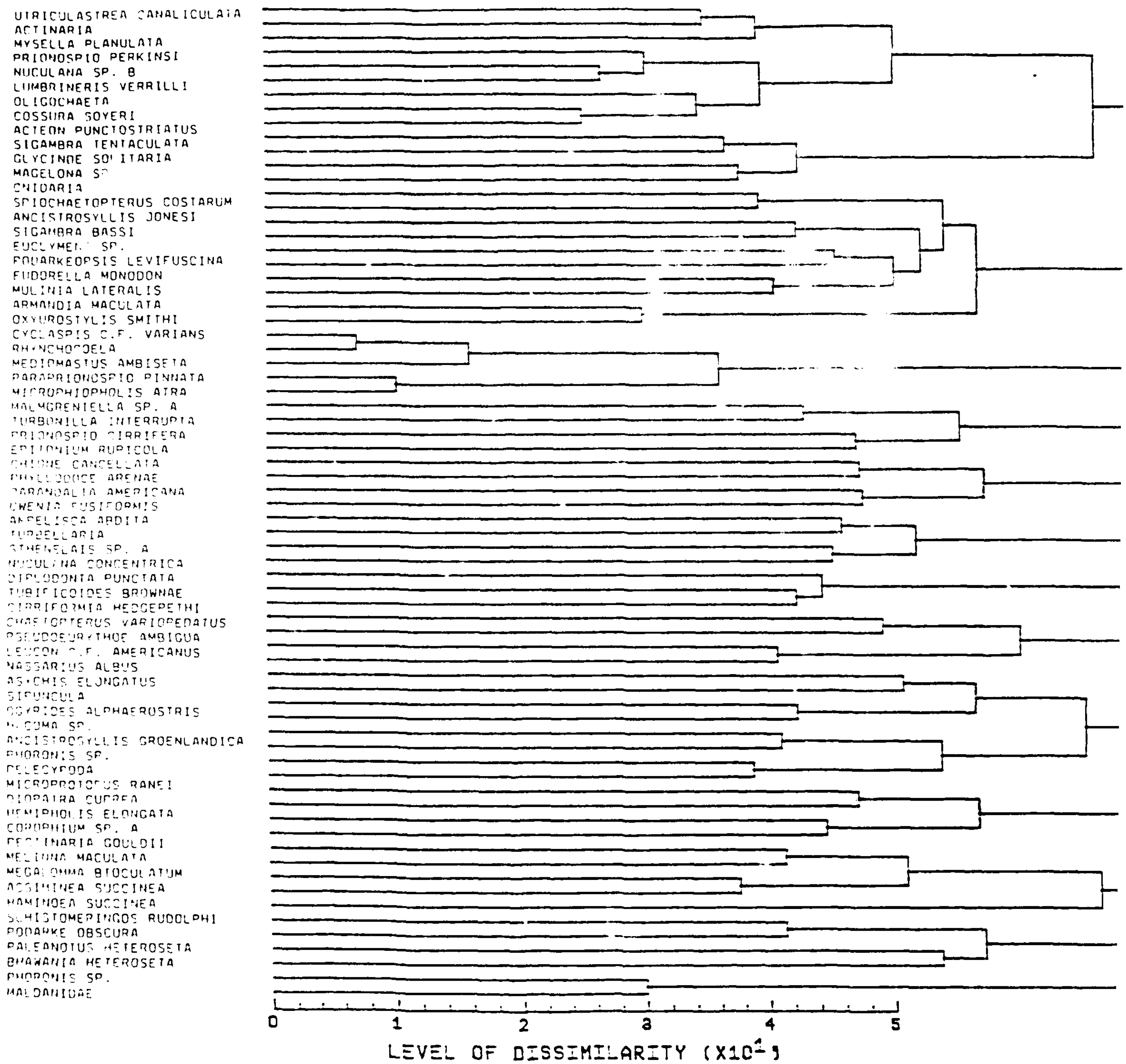


FIGURE 3.2-19. Q-MODE CLUSTER ANALYSIS FOR THE 52-WEEK POST-DISPOSAL SURVEY.



UTRICULASTREA CANALICULATA
ACTINARIA
MYSELLA PLANULATA
PRIONOSPIO PERKINSI
NUCULANA SP. B
LUMBRINERIS VERRILLI
OLIGOCHAETA
COSSURA SOYERI
ACTEON PUNCTOSTRIATUS
SIGAMBRA TENTACULATA
GLYCINDE SOLITARIA
MAGELONA SP
CNIDARIA
SPIOCHAETOPTERUS COSTARUM
ANCISTROSYLLIS JONESI
SIGAMBRA BASSI
EUCLYMENE SP.
PODARKEOPSIS LEVIFUSCINA
EUDORELLA MONODON
MULINIA LATERALIS
ARMANDIA MACULATA
OXYUROSTYLIS SMITHI
CYCLASPIS C.F. VARIANS
RHYNCHOCOELA
MEDIOMASTUS AMBISETA
PARAPRIONOSPIO PINNATA
MICROPHIOPHOLIS ATRA
MALMGRENIELLA SP. A
TURBONILLA INTERRUPTA
PRIONOSPIO CIRRIFERA
EPITONIUM RUPICOLA
CHIONE CANCELLATA
PHYLLODOCE ARENAE
PARANDALIA AMERICANA
OWENIA FUSIFORMIS
AMPELISCA ABDITA
TURBELLARIA
STHENELAIS SP. A
NUCULANA CONCENTRICA
DIPLODONTA PUNCTATA
TUBIFICOIDES BROWNAE
CIRRIFORMIA HEDGEPETHI
CHAETOPTERUS VARIOPEDATUS
PSEUDOEURYTHOE AMBIGUA
LEUCON C.F. AMERICANUS
NASSARIUS ALBUS
ASYCHIS ELONGATUS
SIPUNCULA
OGYRIDES ALPHAEROSTRIS
MACOMA SP.
ANCISTROSYLLIS GROENLANDICA
PHORONIS SP.
PELECYPODA
MICROPROTOPUS RANEI
DIOPATRA CUPREA
HEMIPHOLIS ELONGATA
COROPHIUM SP. A
PECTINARIA GOULDII
MELINNA MACULATA
MEGALOMMA BIOCULATUM
ACTINIAREA SUCCINEA
HAMINOEA SUCCINEA
SCHISTOMERINGOS RUDOLPHI
PODARKE OBSCURA
PALEANOTUS HETEROSETA
BHAWANIA HETEROSETA
PHORONIS SP.
MALDANIDAE
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3
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LEVEL OF DISSIMILARITY (X10-1)

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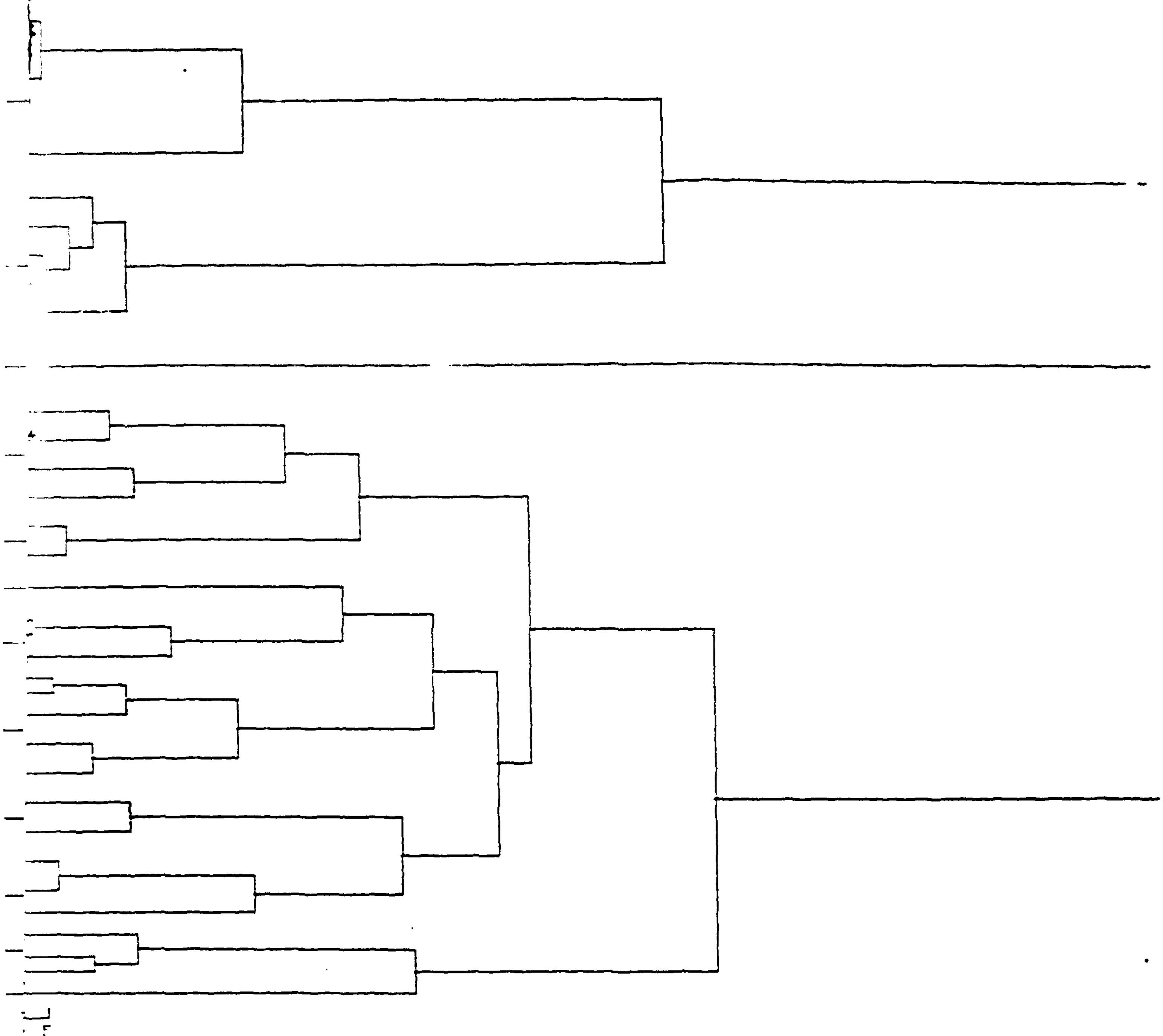

FIGURE 3.2-20. R-MODE CLUSTER ANALYSIS FOR THE 52-WEEK POST-DISPOSAL SURVEY.

The random station results show much less variability in terms of overall numbers since the data from multiple replicates are pooled (Table 3.2-3). Average abundances ranged from 3,713 organisms $-m^{-2}$ (Disposal area, 2-week post-disposal) to a low of 1,710 organisms $-m^{-2}$ (Disposal, 20-week post-disposal). No obvious spatial or temporal trend was notable in the average abundance data from the random station collections probably because any differences were averaged out in the "random" sampling technique.

Number of species ranged from a low of 38 taxa at station C-3-2, 2-week post-disposal sampling to a high of 78 taxa at station C-2-9, 2-week predisposal sampling. A trend of decreasing numbers of species with time was noted at the random sites, paralleling the same trend that was noted at the fixed stations.

The species which dominated the fixed station community, Armandia maculata, Sigambra tentaculata, Podarkeopsis levifuscina, Microphiopholis atra and Balanoglossus c.f. aurantiacus were also the dominants in the random station samples.

Biomass

Total macroinfauna biomass (wet weight) for the major groups and for the dominant taxa are presented in Table 3.2-4 and Figure 3.2-21. Total biomass ranged from 12.4 grams-m^{-2} to 44.74 grams $-m^{-2}$ with the lowest value occurring at the disposal stations, 2 and 6 weeks post-disposal. Echinoderms made up the bulk of the community in terms of biomass. A noted decline in total biomass was observed in the disposal area during the 2 week post-disposal survey concomitant with an increase in biomass in the fringe and reference areas. By the 6-week sampling however, the total biomass at the disposal site was approaching levels similar to the other areas.

Table 3.2-3. Average macroinfauna abundance and number of species from the random station sampling.

	MONTH	STATION	AVERAGE±STD	Total # Spec
2-Week Predisposal	DEC	C-2-9	2774±523	78
		C-4-1	3596±2207	66
		D-4-6	2746±492	76
		D-5-5	2434±1313	61
		F-3-5	4318±1565	63
		F-5-8	2317±667	59
2-Week Post-disposal	JAN	C-2-2	2477±376	55
		C-3-2	2537±901	38
		D-5-6	2168±652	58
		D-5-7	3712±916	61
		F-3-7	2320±682	52
		F-3-8	2904±1077	62
6-Week Post-disposal	FEB	C-1-4	2534±765	57
		C-4-10	2735±652	58
		D-4-4	1766±714	42
		D-5-5	2164±571	51
		F-3-5	2237±897	43
		F-6-4	2573±1041	52
20-Week Post-disposal	MAY	C-1-8	1923±480	48
		C-3-4	2072±944	45
		D-4-7	1708±639	51
		D-5-6	2255±877	50
		F-4-2	3831±1166	49
		F-5-8	2124±701	43
52 Week Post-disposal	JAN	C-1-2	2509±739	59
		C-3-9	2069±928	51
		D-4-7	2788±1136	53
		D-5-5	3680±1146	69
		F-4-3	3643±1360	56
		F-6-6	4985±919	63

Station prefix: C = Reference Stations, D = Disposal Stations, F = Fringe Stations.

Since the organisms dominating the total biomass were the larger taxa (echinoderms) it is conceivable that the majority of the individuals could have migrated out of the disposal area following disposal. However it is likely many were simply buried. Since a significant biomass of these organisms were found 2-weeks post-disposal there is some evidence that at least some individuals may have burrowed up through the thin layer.

Biomass of the other individual taxa showed variable trends. Armandia and other polychaete biomass showed slightly higher levels at the 2-week post-disposal period indicating this group rebounded rapidly following the disposal event. Since lower numbers of individuals of these organisms were found 2 and 6-weeks post-disposal, we conclude that the organisms must have been larger individuals than those collected predisposal. Lowered biomass in the disposal area was noted for the crustacea and hemicordates following the disposal event.

Recruitment

The analysis of the additional samples for recruitment are presented in Table 3.2-5 and Figure 3.2-22. Based on the observed information, there were no major recruitment events during the winter months of December, January and February. A decline can be seen in the number of organisms in the recruitment samples collected in January when compared to the December samples. In part this lack of recruitment is probably due to the sparse amount of reproduction usually found during the colder months. In any case the decline was noted throughout the study area including the fringe and reference areas. It should be noted that meiofauna taxa, nematodes and copepods, dominated all the recruitment samples indicating a low amount of macroinfauna recruitment. Of the truly macroinfauna taxa, polychaetes were the most dominant taxa in the recruitment samples.

Table 3.2-4. Macroinfauna Biomass Based on the Fixed Station Data. Reported in grams $-m^{-2}$.

	PREDISPOSAL			2-Week Post			6-Week Post			20-Week Post			52-Week Post		
	R	F	D	R	F	D	R	F	D	R	F	D	R	F	D
POLYCHAETES	4.68	1.90	0.59	7.90	1.90	1.37	0.76	0.98	0.87	2.13	2.74	1.43	0.75	0.78	0.86
ARMANDIA	0.81	0.90	1.51	2.38	3.25	2.16	0.90	2.91	0.64	0.00	0.00	0.00	0.00	0.00	0.00
CRUSTACEA	0.81	0.78	0.73	0.98	1.01	0.36	0.53	0.11	0.17	0.03	0.08	0.06	0.56	0.28	0.00
MOLLUSCA	1.62	0.92	0.78	0.39	7.14	0.31	0.45	0.76	7.45	0.36	6.08	1.29	0.28	0.56	0.28
ECHINODERMS	14.11	16.72	21.17	17.11	27.19	7.73	16.07	12.52	5.99	22.12	25.56	22.62	35.47	28.99	24.48
HEMICHORDATES	3.14	2.18	1.32	4.56	4.26	0.48	1.99	1.29	0.73	1.09	0.73	0.17	0.00	0.00	0.00
TOTAL BIOMASS	25.17	23.41	26.10	33.32	44.74	12.40	20.69	18.56	15.85	25.73	35.20	25.56	37.06	30.61	25.63

R = Reference Stations
F = Fringe Stations
D = Disposal Stations

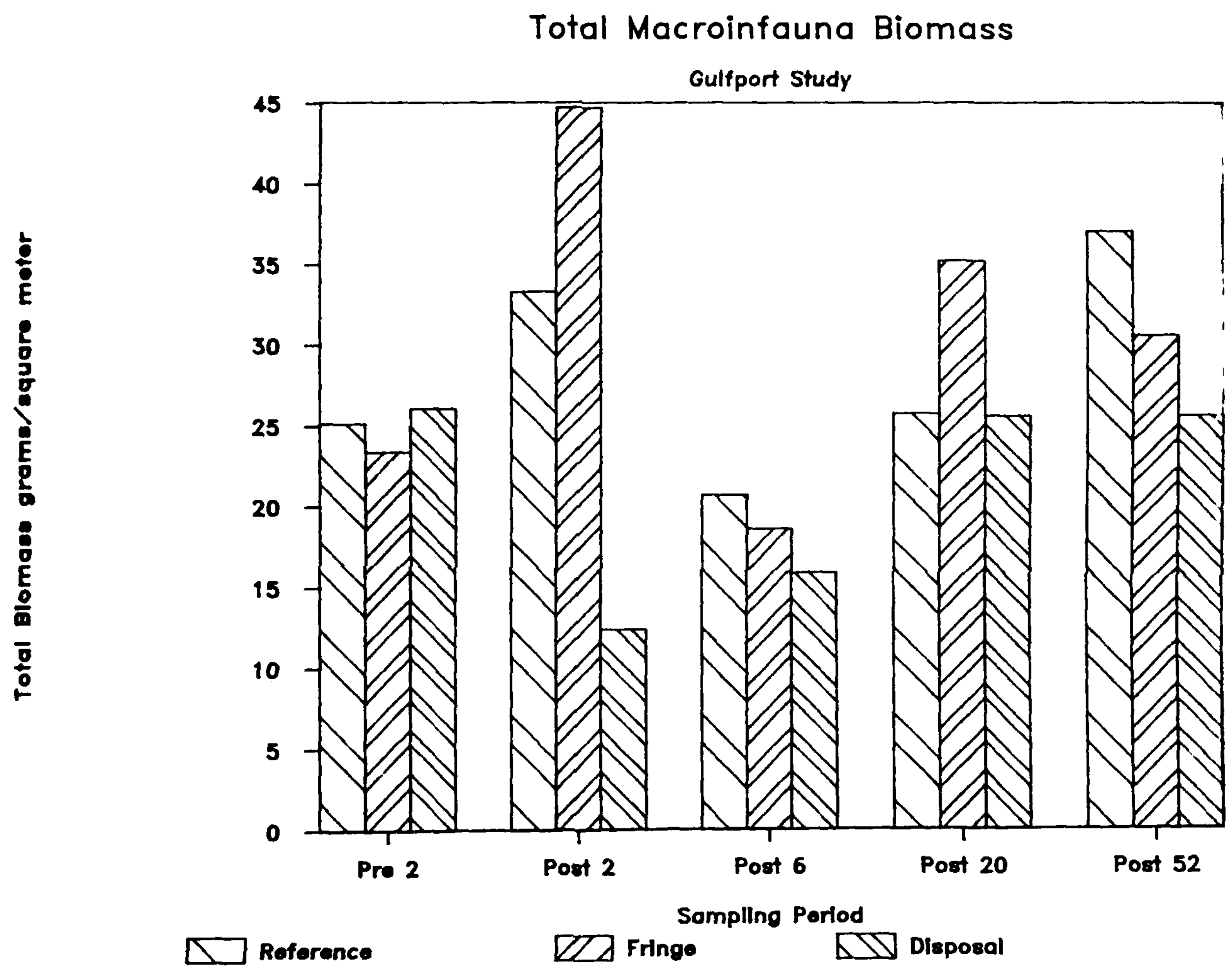

FIGURE 3.2–21. TOTAL BIOMASS OF MACROINFAUNA COLLECTED AT GULFPORT HARBOR. REPORTED IN GRAMS/SQUARE METER

Table 3.2-5. Results of analysis on Recruitment Samples. Numbers Reported in Organisms/cm^2.

		Nematodes	Polychaeta	Crustacea	Mollusca
Pre					
	Reference	1.70	1.53	1.26	0.24
	Fringe	2.28	1.41	1.96	0.39
	Disposal	1.82	0.44	0.85	0.12
Post 2					
	Reference	0.81	0.48	0.45	0.17
	Fringe	0.98	0.57	0.39	0.12
	Disposal	0.62	0.43	0.07	0.04
Post 6					
	Reference	0.69	0.52	0.23	0.1[illegible]
	Fringe	0.63	0.45	0.22	0.18
	Disposal	0.70	0.46	0.19	0.12

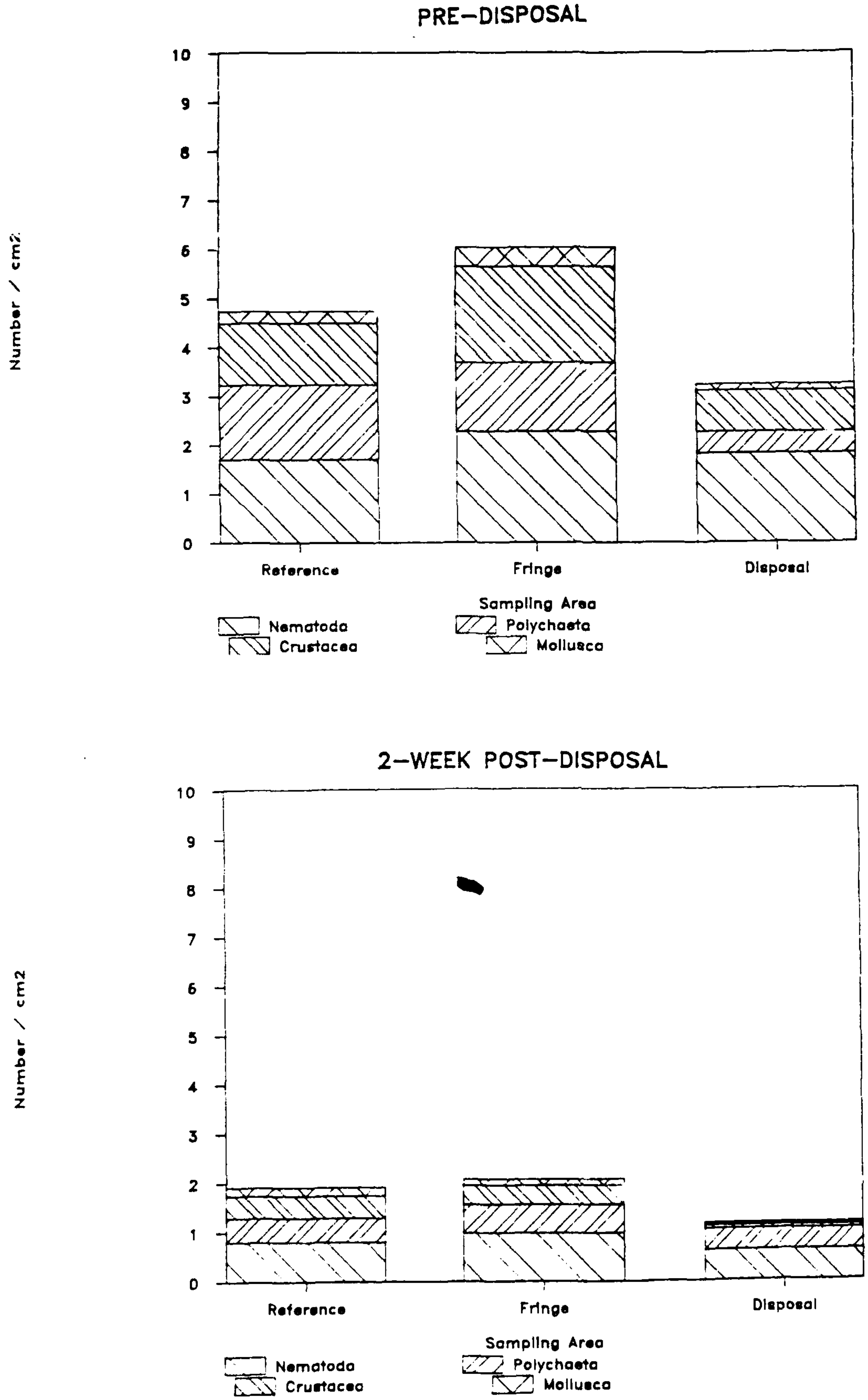

FIGURE 3.2-2
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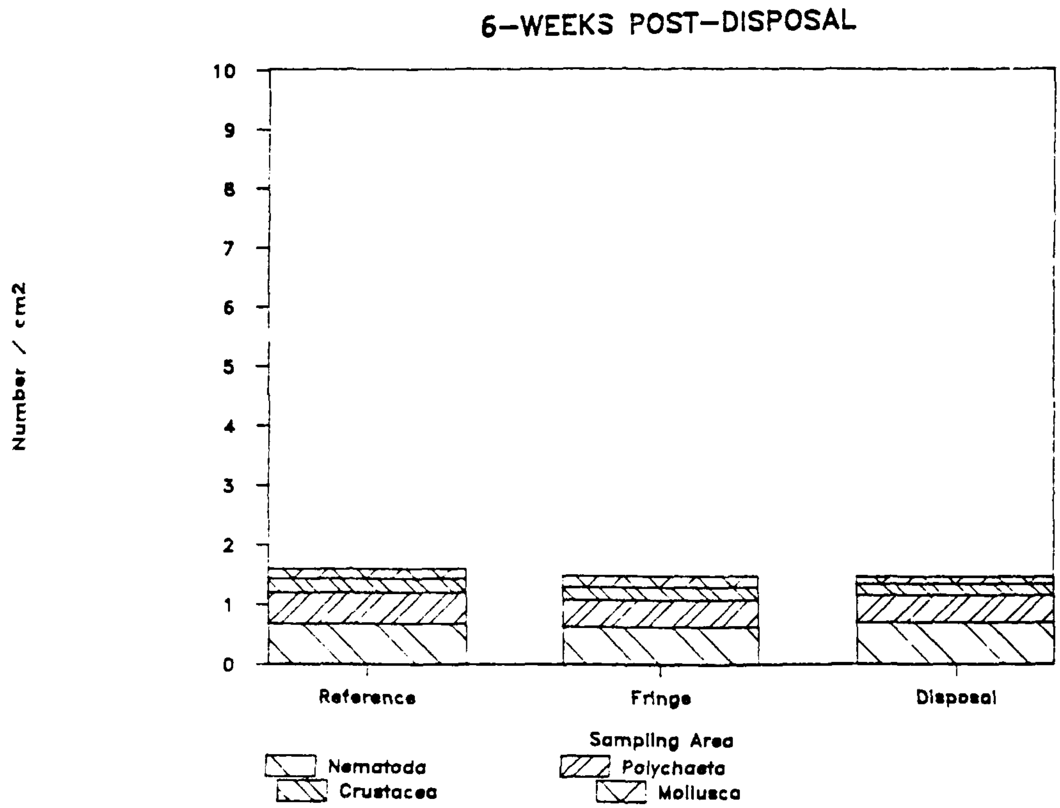


FIGURE 3.2-22. RECRUITMENT SAMPLE ANALYSIS FOR THE GULFPORT HARBOR STUDY. REPORTED IN #/CM SQUARED.

3.2.2 Vertical Sediment Profile Imagery.

The successional stage of the benthos can range from azoic communities (0), pioneering (I), intermediate (II) to climax (III) communities as described by Germano and Rhoads (1986). Pioneering communities are dominated by smaller organisms with little ability to burrow more than a few millimeters into the substrate. The taxa are dominated by deposit feeding organisms with sucking type of feeding apparatus. Climax communities are dominated by larger invertebrates that are adapted to deep burrowing activity. The taxa contain many larger "top-down feeders" and a large variety of predatory type organisms.

Disregarding the stations with obvious physical disturbances (mud lumps, clasts etc.), no azoic areas were found during any of the monitoring periods. Most of the areas were classified as late Stage II or Stage III in the sediment profile images. Typical larger type organisms were found such as the acorn worm Balanoglossus, the brittlestar Microphiopholis and especially the large holothurian Leptosynapta which are indicative of the advanced stage III community. The presence of dense tube mats, primarily on the dredged materials following the disposal event (2 and 6-weeks post-disposal) indicated enhanced survival or enhanced settlement relative to background conditions or both. These images were classified as Stage I over a Stage II or III community, and represent a decline in the overall benthic community because of the dredged material disposal. The community returned to a class III community by the 20-week disposal period indicating a recovery of the community had ocurred. The community during the 52-week period was also a class III type as noted during the predisposal and 20-week post-disposal periods.

3.2.3 Demersal Organisms

Unlike the more sessile macroinfauna community described above, the fisheries community represents a highly dynamic group of populations with the ability to avoid numerous environmental perturbations, both natural and manmade. Also, since demersal organisms usually represent the next trophic level, ie. they feed upon the macroinfauna community, their response can be another indication of environmental changes.

During all fisheries collections a total of 11,768 fishes were collected, representing 38 species within 23 families (Table 3.2-6), during a series of five field efforts in December 1986, January, February and May 1987, and January 1988. The most abundant vertebrate species collected was Anchoa mitchilli, bay anchovy, with 4,507 individuals representing 38.30 percent of the overall total. Arius felis, hardhead catfish, was the next most abundant species with 3,779 specimens representing 32.11 percent of the overall total. The third most abundant taxon was Micropogonias undulatus, Atlantic croaker, with 1,320 individuals representing 11.22 percent of the overall total. These and other overall vertebrate species totals and percent composition data are presented in Table 3.2-7. Of the 38 species collected, the ten most abundant represent over 95 percent of the overall total.

The invertebrate taxa represented a smaller but nonetheless important portion of the fisheries collections with white shrimp, Penaeus setiferus, and blue crab, Callinectes sapidus, representing over 50 percent of the total invertebrates collected (Table 3.2-8).

Over the course of the monitoring period, distinct variations in the major vertebrate species abundance and composition were present (Table 3.2-9). During December 1986 (2-week predisposal), 901 fishes, representing 17 species, were collected with Anchoa mitchilli being the most abundant.

Samples from January (2-week post-disposal) collections showed a distinct drop in both number of species and species abundance. A total of 483 individuals, representing 14 species, were collected with Anchoa mitchilli again being the most abundant. February (6-week post-disposal) field collections totalled 1,814 individuals, though over 58 percent were represented by one species of the 23 collected, Anchoa mitchilli. May (20-week post-disposal) collections were represented by 29 species and 7,678 total individuals of which the Arius felis was the most abundant. June (52-week post-disposal) collections were again dominated by Anchoa mitchilli with only ten vertebrate taxa collected.

Table 3.2-6. Phylogenetic listing of all organisms collected in Gulfport Harbor trawl samples.

Phylum
Class
Order
Family
Genus species
Mollusca
Gastropoda
Archaegastropoda
Naticidae
Polinices sp.
Cephalopoda
Teuthoidea
Loliginidae
Lolliguncula brevis
Arthropoda
Crustacea
Stomatopoda
Squillidae
Squilla empusa
Decapoda
Penaeidae
Penaeus aztecus
Penaeus setiferus
Sicyonia sp.
Alpheidae
Alpheus heterochelis
Paguridae
Pagurus sp.
Porcellanidae
Portunidae
Callinectes sapidus
Chordata
Chondrichthyes
Rajiformes
Dasyatidae
Dasyatis sabina
Osteichthyes
Clupeiformes
Clupeidae
Brevoortia patronus
Dorosoma petenense
Engraulidae
Anchoa hepsetus
Anchoa mitchilli

Table 3.2-6. (Continued).

Phylum / Class / Order / Family / Genus species
Siluriformes
Ariidae
Arius felis
Batrachoidiformes
Batrachoididae
Porichthys plectrodon
Gadiformes
Gadidae
Urophycis floridana
Gasterosteiformes
Syngnathidae
Hippocampus erectus
Syngnathus louisianae
Perciformes
Pomatomidae
Pomatomus saltatrix
Carangidae
Chloroscombrus chrysurus
Sparidae
Archosargus probatocephalus
Lagodon rhomboides
Sciaenidae
Bairdiella chrysoura
Cynoscion arenarius
Cynoscion nebulosus
Leiostomus xanthurus
Larimus fasciatus
Menticirrhus americanus
Micropogonias undulatus
Mugilidae
Mugil cephalus
Gobiidae
Gobionellus hastatus
Trichiuridae
Trichiurus lepturus
Scombridae
Scomberomorus maculatus
Stromateidae
Peprilus alepidotus
Peprilus triacanthus

Table 3.2-6. (Continued).

Phylum / Class / Order / Family / Genus species
Triglidae
Prionotus rubio
Prionotus scitulus
Prionotus tribulus
Pleuronectiformes
Bothidae
Ancylopsetta quadrocellata
Citharichthys spilopterus
Etropus crossotus
Soleidae
Trinectes maculatus
Cynoglossidae
Symphurus plagiusa
Tetraodontiformes
Balistidae
Monacanthus hispidus
Tetraodontidae
Sphoeroides parvus
Diodontidae
Chilomycterus schoepfi

Table 3.2-7. Overall abundance and percent of the major vertebrate taxa collected during the fisheries survey.

Taxa	Total	Percent Composition
Anchoa mitchilli	4,507	38.30
Arius felis	3,779	32.11
Micropogonias undulatus	1,320	11.22
Prionotus tribulus	401	3.41
Peprilus triacanthus	301	2.57
Sphoeroides parvus	274	2.33
Dorosoma petenense	238	2.02
Brevoortia patronus	215	1.83
Etropus crossotus	110	.94
Trichiurus lepturus	103	.88
Cynoscion arenarius	79	.67
Leiostomus xanthurus	78	.66
Symphurus plagiusa	74	.63
Trinectes maculatus	73	.62
Menticirrhus americanus	63	.54
Bairdiella chrysoura	43	.37
Urophycis floridana	33	.28
Dasyatis sabina	12	*
Citharichthys spilopterus	9	*
Larimus fasciatus	8	*
Peprilus alepidotus	7	*
Anchoa hepsetus	6	*
Hippocampus erectus	5	*
Gobionellus hastatus	4	*
Chloroscombrus chrysurus	3	*
Cynoscion nebulosus	3	*
Prionotus rubio	3	*

Table 3.2-7. (Continued).

Taxa	Total	Percent Composition
Prionotus scitulus	3	*
Ancylopsetta quadrocellata	2	*
Porichthys plectrodon	2	*
Syngnathus louisianae	2	*
Archosargus probatocephalus	2	*
Chilomycterus schoepfi	1	*
Lagodon rhomboides	1	*
Monacanthus hispidus	1	*
Mugil cephalus	1	*
Pomatomus saltatrix	1	*
Scomberomorus maculatus	1	*
Total	11,768	

* Less than one-tenth percent.

Table 3.2-8. Overall abundance and percent composition of the major invertebrate taxa collected during the fisheries survey.

Taxa	Total	Percent Composition
Penaeus setiferus	337	27.94
Callinectes sapidus	287	23.80
Squilla empusa	209	17.33
Lolliguncula brevis	135	11.19
Penaeus aztecus	114	9.45
Totals	998	

Table 3.2-9. Abundance by field effort, for the major vertebrate taxa collected during the fisheries survey.

Taxa	2 Week Pre*	2 Week Post*	6 Week Post*	20 Week Post*	52 Week Post*
Arius felis	0	1	15	3,763	0
Anchoa mitchilli	614	326	1,054	1,733	780
Micropogonias undulatus	21	1	42	1,251	5
Prionotus tribulus	68	63	151	116	3
Sphoeroides parvus	113	9	139	7	6
Dorosoma petenense	0	0	49	184	5
Peprilus triacanthus	28	22	15	153	83
Brevoortia patronus	7	0	199	3	6
Etropus crossotus	15	27	28	39	1
Trichiurus lepturus	1	0	0	102	0

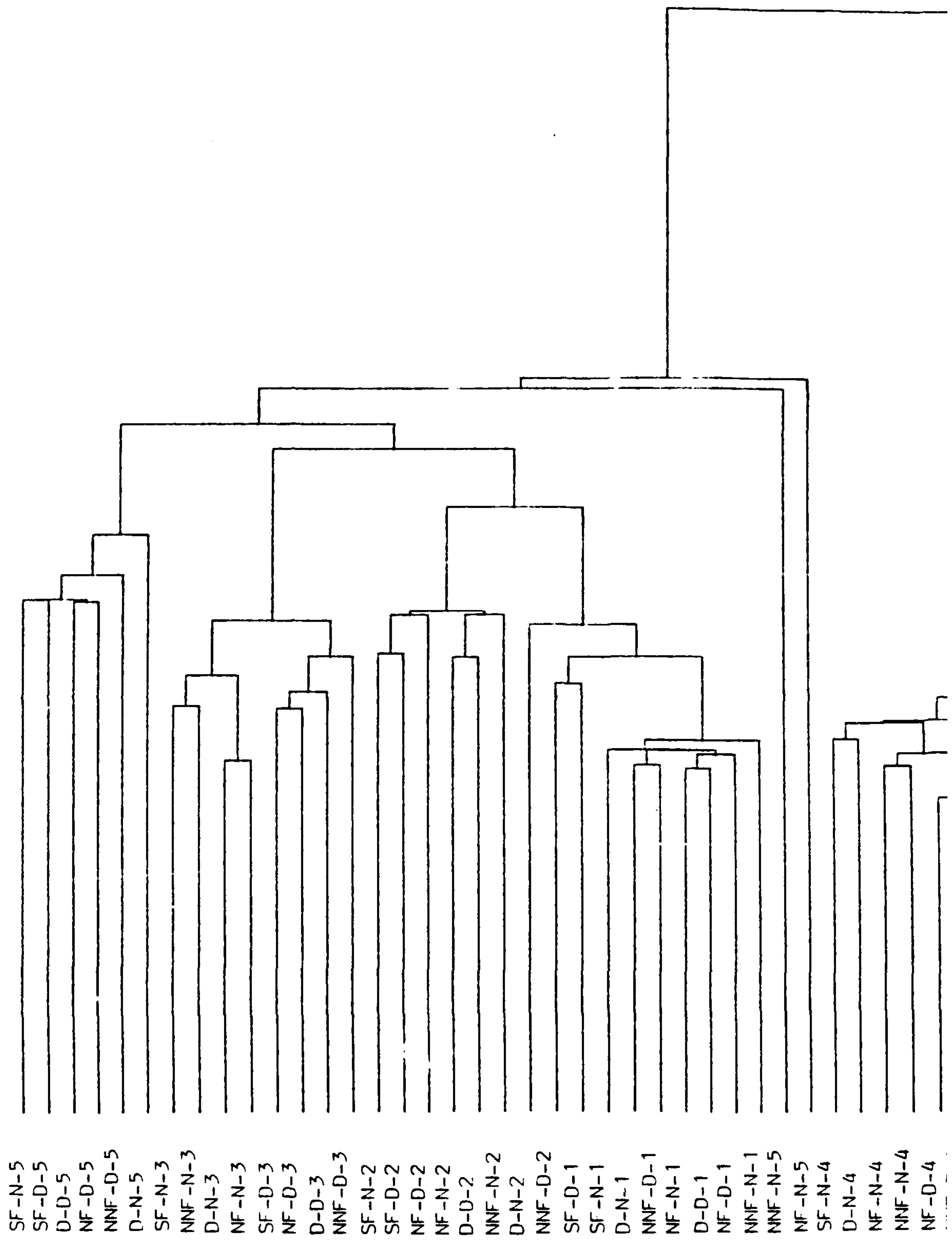
* Pre and post-dredged material disposal.

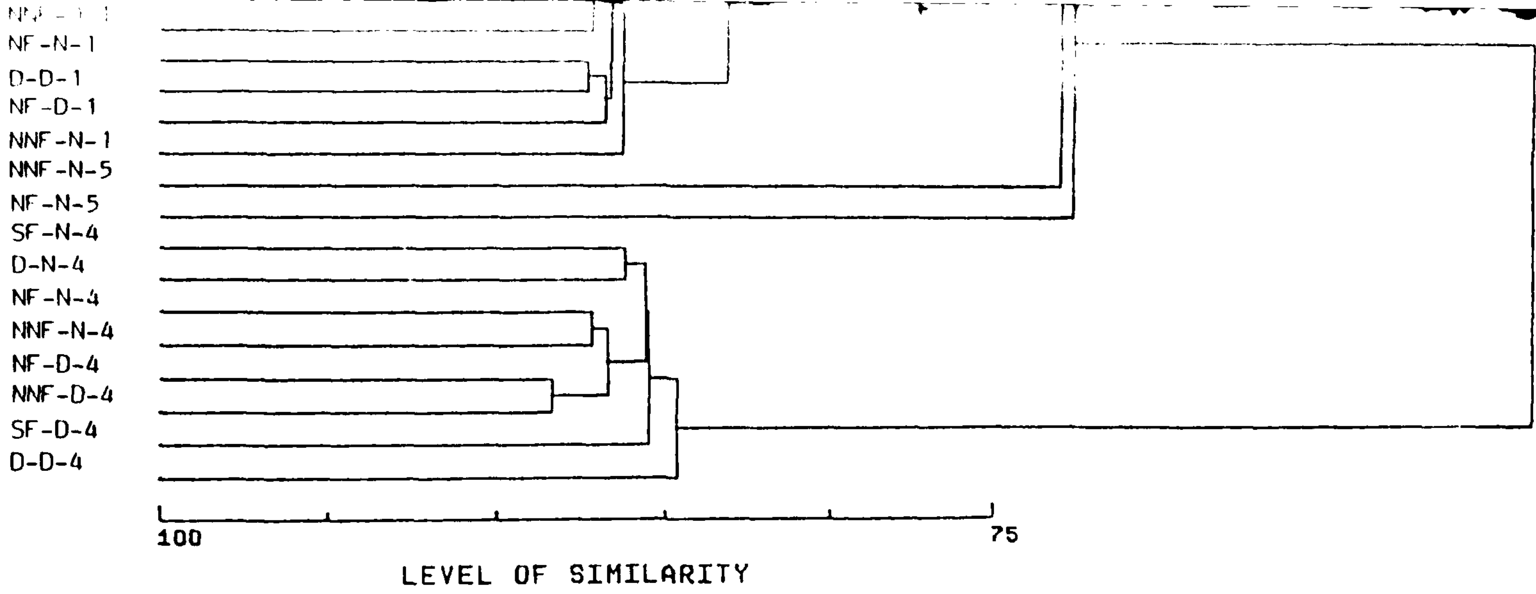
In order to detect subtle shifts in the demersal organism community, we have employed various descriptive statistics including the previous tabular displays of summary data and normal (Q-mode) and inverse (r-mode) cluster analyses. These techniques provide the most useful method of describing the data and can then be related to similar techniques used for describing the macroinfauna community. In this way, the relationships between the dredging impacts seen in one community can be related to observed changes in another.

The Q-mode cluster analyses, Figures 3.2-23 through 3.2-30, were developed using the Bray-Curtis resemblance measure. These figures present a series of similarity groupings, by sampling period, for all diel collections within the four sampling areas. This allows for spatial as well as diel comparisons. Tables 3.2-10 through 3.2-17 are arranged respective to the figures providing tabular data summaries and a reference for both sampling area (Q-mode) and species (r-mode) designations. Sampling area designations go from left to right and species designations go from top to bottom. The designations vary from table to table.

The Q-mode cluster analysis of all sampling periods, Figure 3.2-23, shows a distinct pattern of temporal groupings, with the May sampling period grouping separately from the cold month monitoring periods. Within each of the separate cold month monitoring periods, the disposal area collections show at least one close linkage to a northern fringe area sampling period. Only during May does the disposal area collection link with a southern fringe area sampling period.

The Q-mode analysis of all sampling periods, Figure 3.2-24, which considers only the vertebrates, displays a similar temporal grouping pattern for the sampling periods. The sampling in the month of May 1987, again forms an outlier grouping. This pattern almost disappears. however, when considering only the invertebrates, Figure 3.2-25. The May sampling period also linked with the cold month monitoring periods, with the 52-week post-disposal period not forming a grouping at all.


SF-N-5
SF-D-5
D-D-5
NF-D-5
NNF-D-5
D-N-5
SF-N-3
NNF-N-3
D-N-3
NF-N-3
SF-D-3
NF-D-3
D-D-3
NNF-D-3
SF-N-2
SF-D-2
NF-D-2
NF-N-2
D-D-2
NNF-N-2
D-N-2
NNF-D-2
SF-D-1
SF-N-1
D-N-1
NNF-D-1
NF-N-1
D-D-1
NF-D-1
NNF-N-1
NNF-N-5
NF-N-5
SF-N-4
D-N-4
NF-N-4
NNF-N-4
NF-D-4

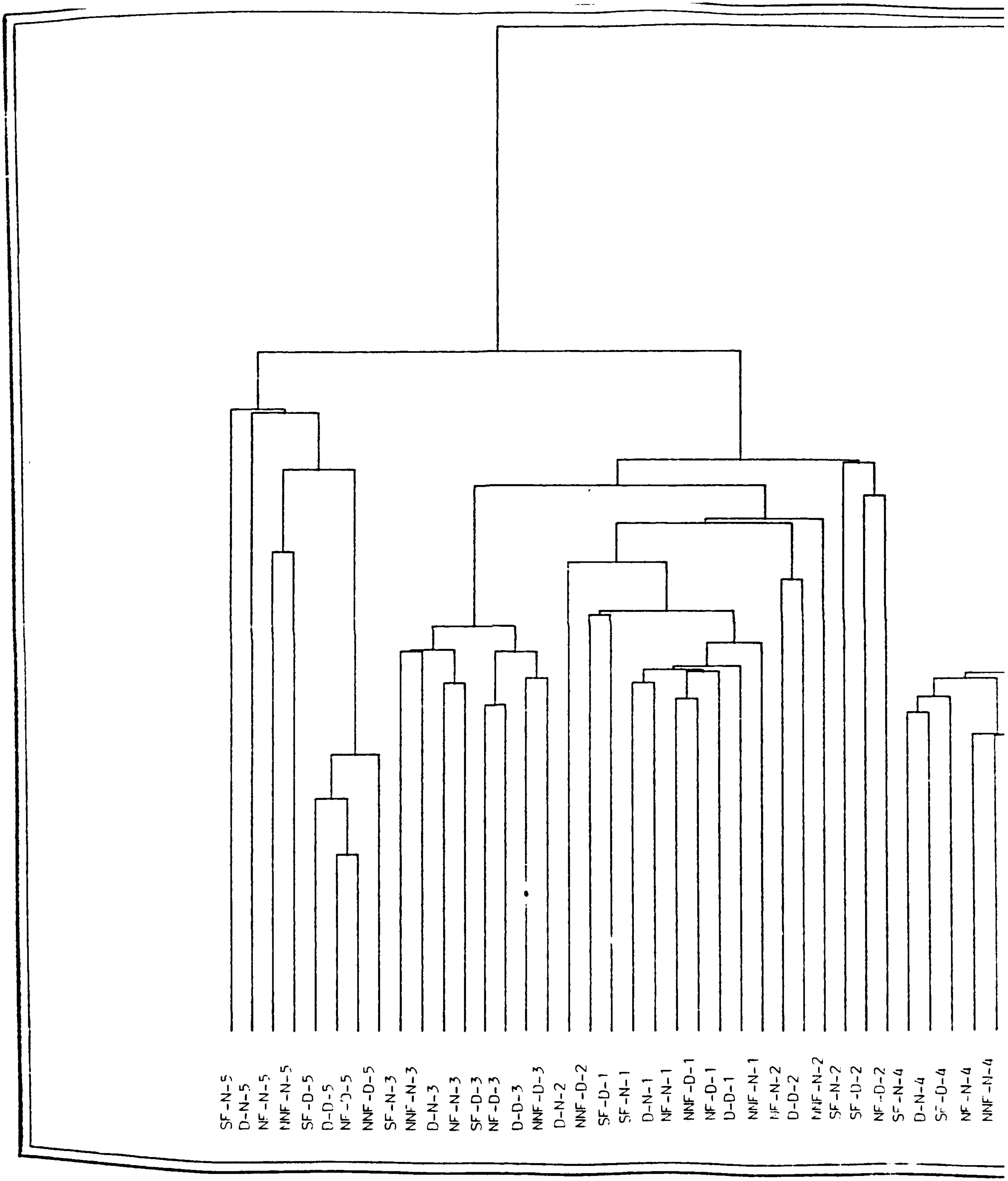


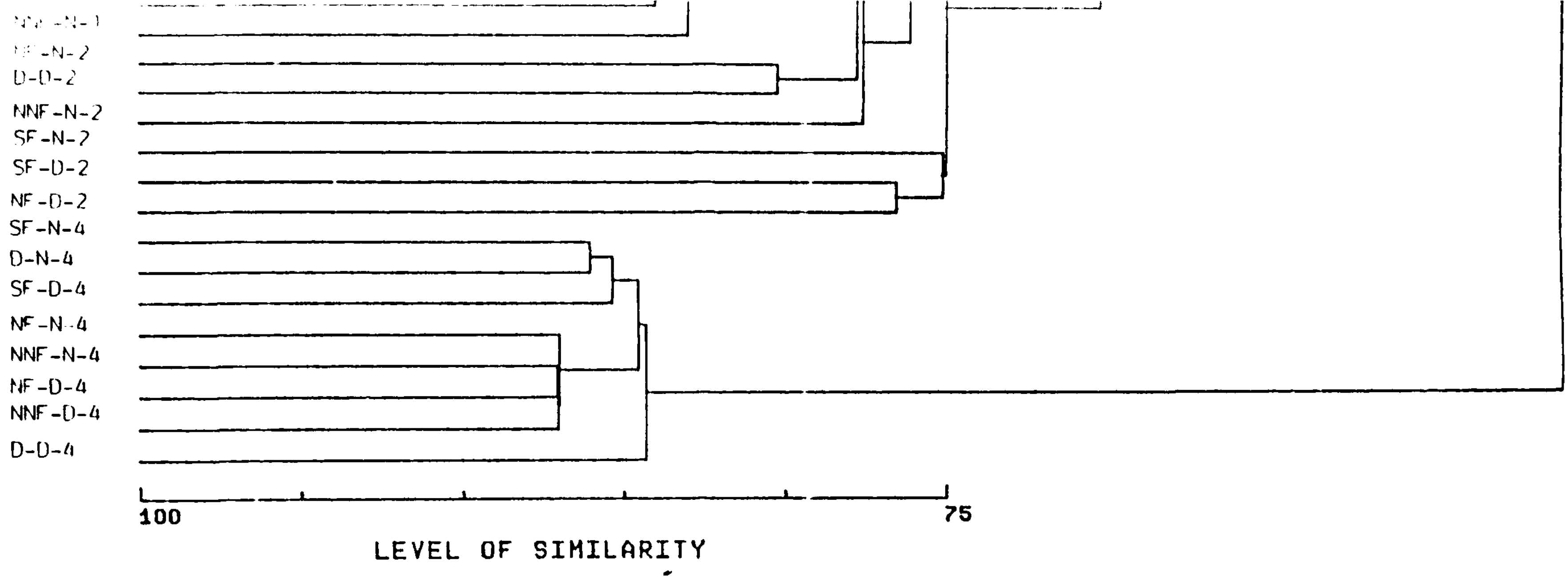
NNF - Reference
NF - North Fringe
D - Disposal
SF - South Fringe

D - Day
N - Night

1 - 2 week pre-disposal
2 - 2 week post-disposal
3 - 6 week post-disposal
4 - 20 week post-disposal
5 - 52 week post-disposal

FIGURE 3.2-23 Q-MODE CLUSTER ANALYSIS OF THE GULFPORT FISHERIES COLLECTIONS, VERTEBRATES AND INVERTEBRATES.


SF-N-5
D-N-5
NF-N-5
NNF-N-5
SF-D-5
D-D-5
NF-D-5
NNF-D-5
SF-N-3
NNF-N-3
D-N-3
NF-N-3
SF-D-3
NF-D-3
D-D-3
NNF-D-3
D-N-2
NNF-D-2
SF-D-1
SF-N-1
D-N-1
NF-N-1
NNF-D-1
NF-D-1
D-D-1
NNF-N-1
NF-N-2
D-D-2
NNF-N-2
SF-N-2
SF-D-2
NF-D-2
SF-N-4
D-N-4
SF-D-4
NF-N-4
NNF-N-4

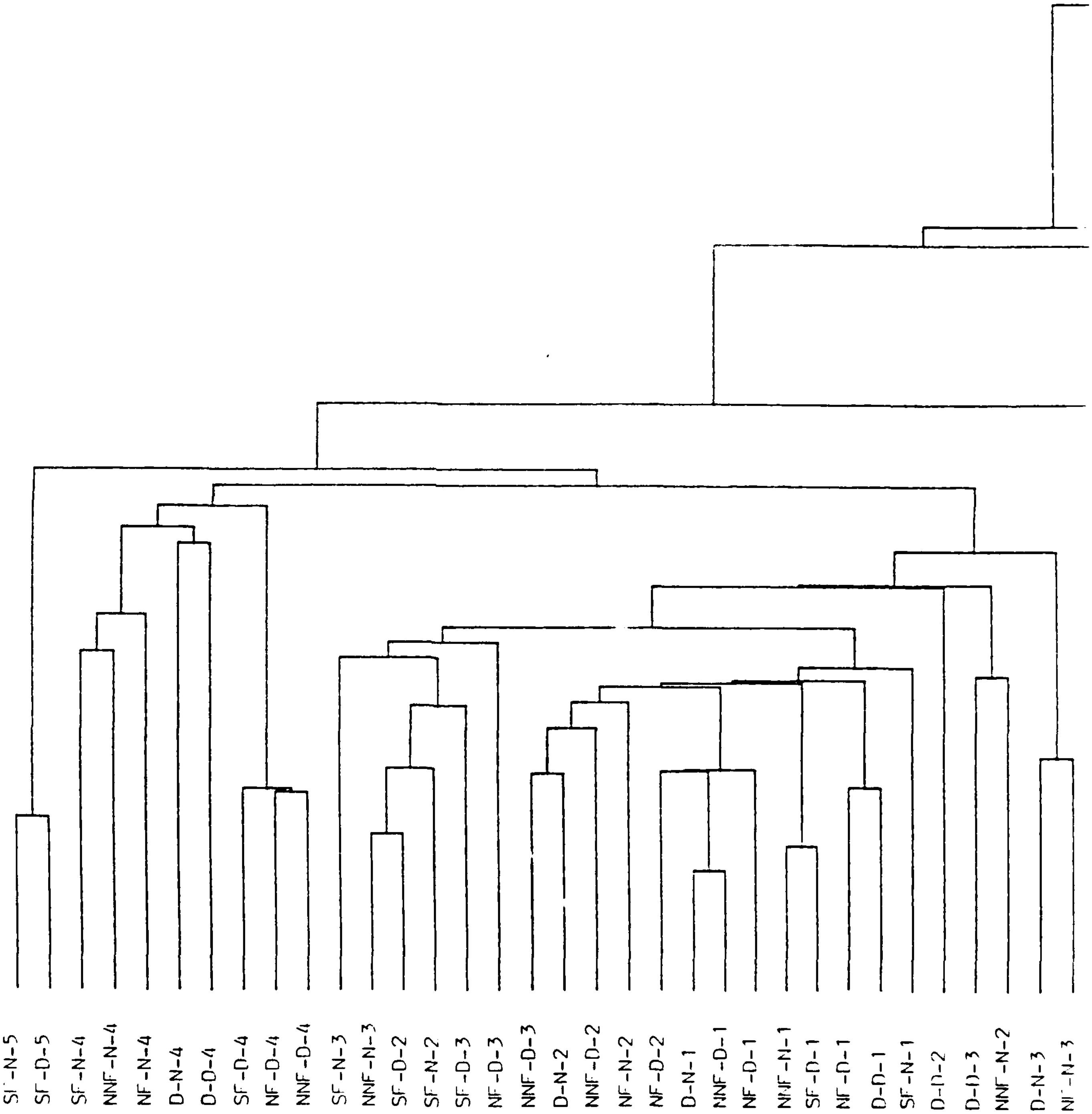


NNF - Reference
NF - North Fringe
D - Disposal
SF - South Fringe

D - Day
N - Night

1 - 2 week pre-disposal
2 - 2 week post-disposal
3 - 6 week post-disposal
4 - 20 week post-disposal
5 - 52 week post-disposal

FIGURE 3.2-24 Q-MODE CLUSTER ANALYSIS OF THE GULFPORT FISHERIES COLLECTIONS, VERTEBRATES ONLY.



SI -N-5
SF-D-5
SF-N-4
NNF-N-4
NF-N-4
D-N-4
D-D-4
SF-D-4
NF-D-4
NNF-D-4
SF-N-3
NNF-N-3
SF-D-2
SF-N-2
SF-D-3
NF-D-3
NNF-D-3
D-N-2
NNF-D-2
NF-N-2
NF-D-2
D-N-1
NNF-D-1
NF-D-1
NNF-N-1
SF-D-1
NF-D-1
D-D-1
SF-N-1
D-D-2
D-D-3
NNF-N-2
D-N-3
NI -N-3

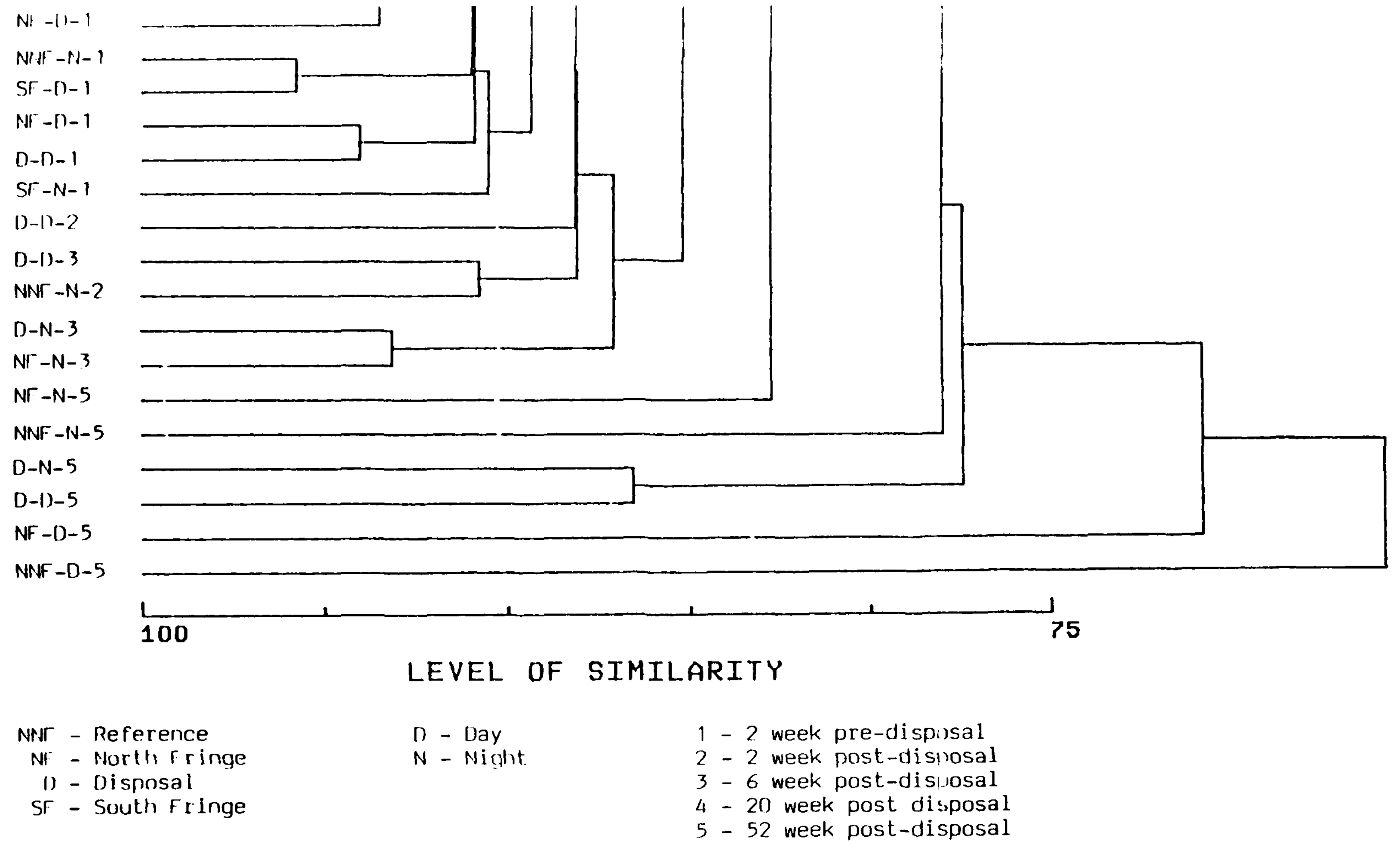


FIGURE 3.2–25 Q–MODE CLUSTER ANALYSIS OF FISHERIES INVERTEBRATES FROM ALL COLLECTION PERIODS.

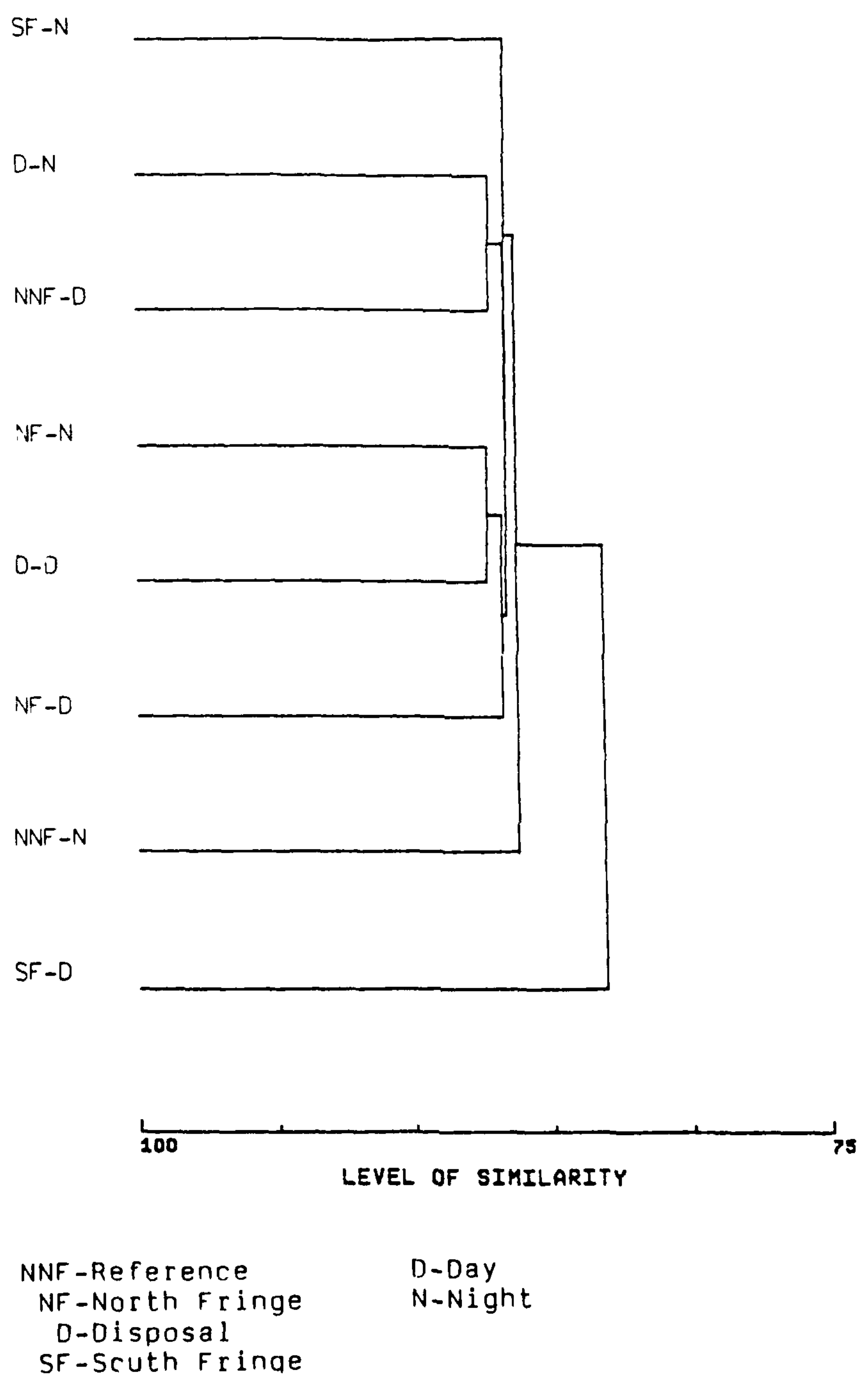
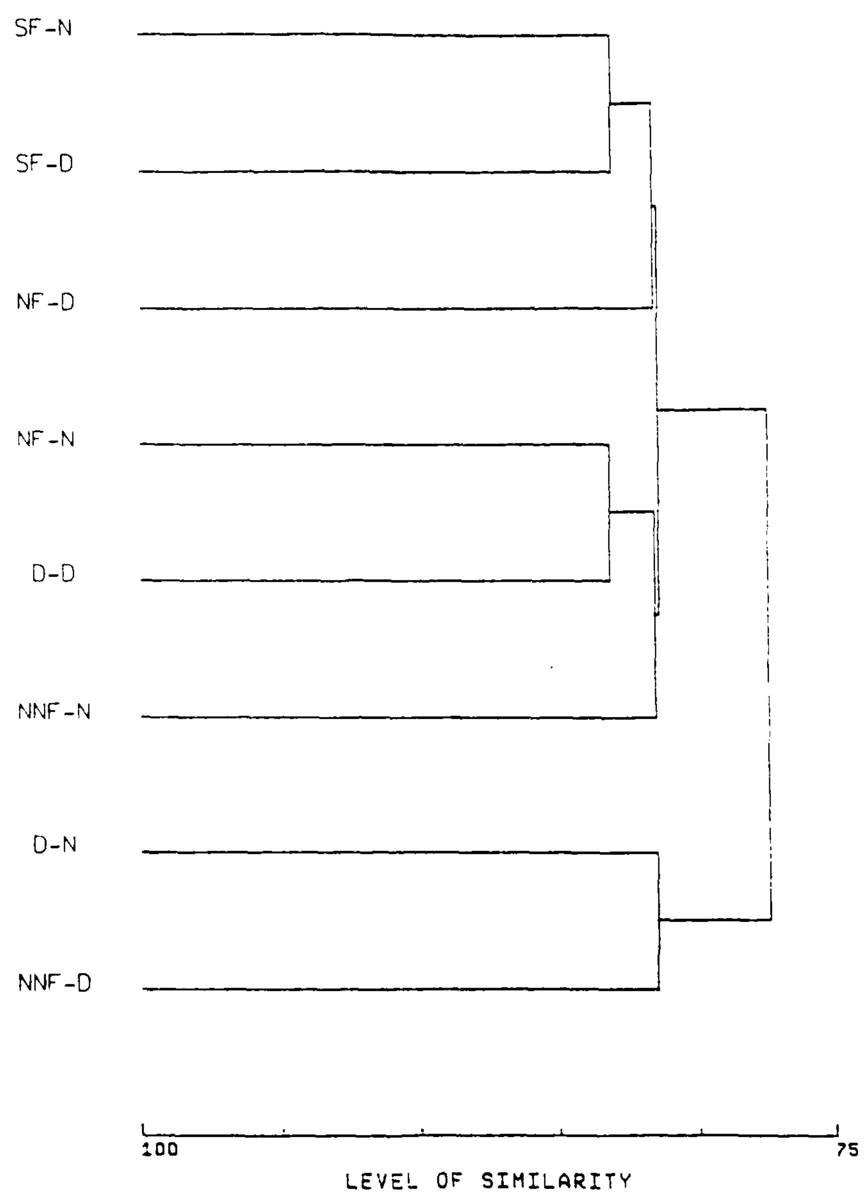


FIGURE 3.2-26 Q-MODE CLUSTER ANALYSIS OF GULFPORT, 2-WEEK PRE-DISPOSAL, FISHERIES COLLECTION PERIODS.



NNF-Reference
NF-North Fringe
D-Disposal
SF-South Fringe

D-Day
N-Night

FIGURE 3.2-27 Q-MODE CLUSTER ANALYSIS OF GULFPORT, 2-WEEK POST-DISPOSAL, FISHERIES COLLECTION PERIODS.

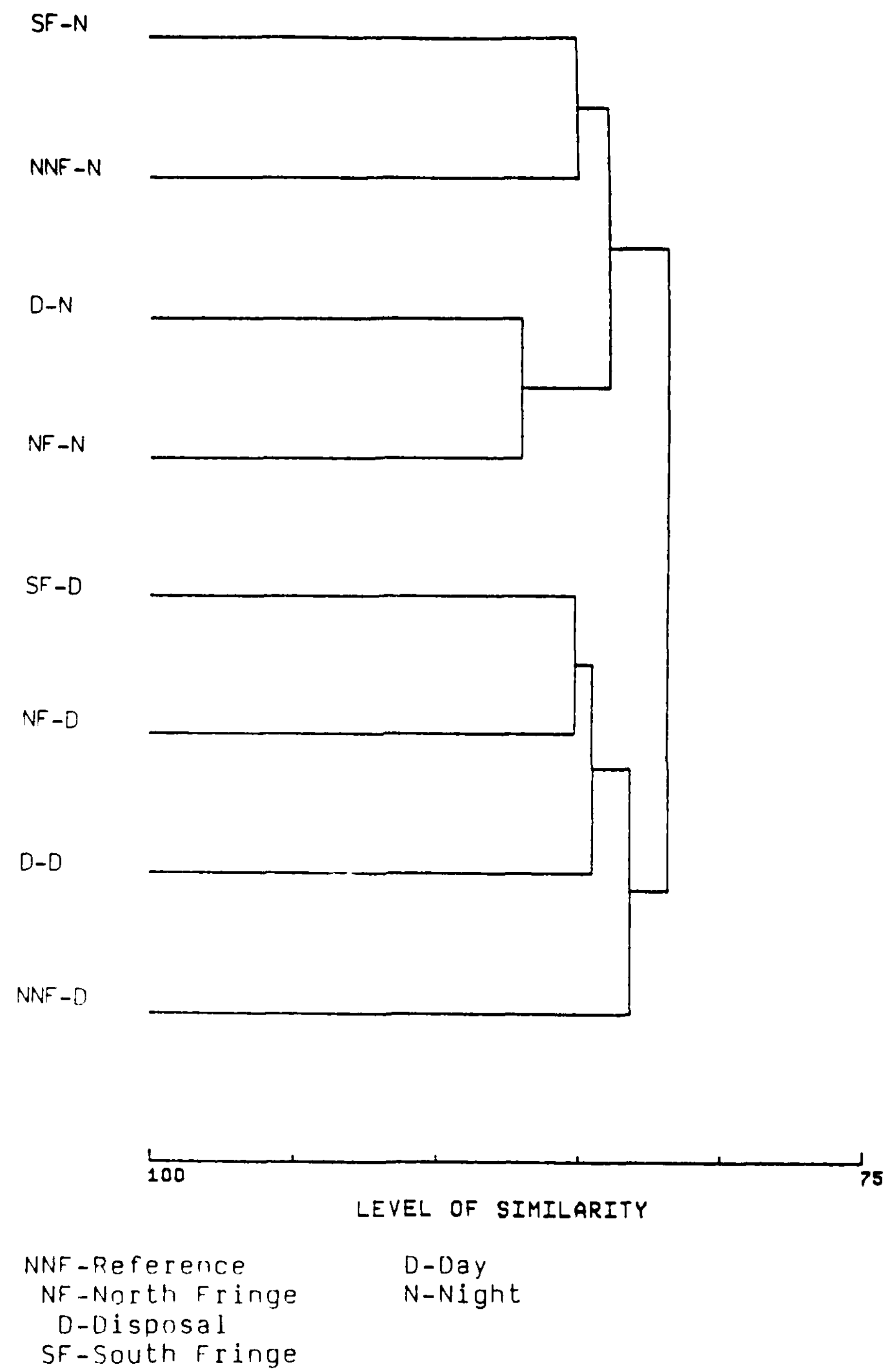
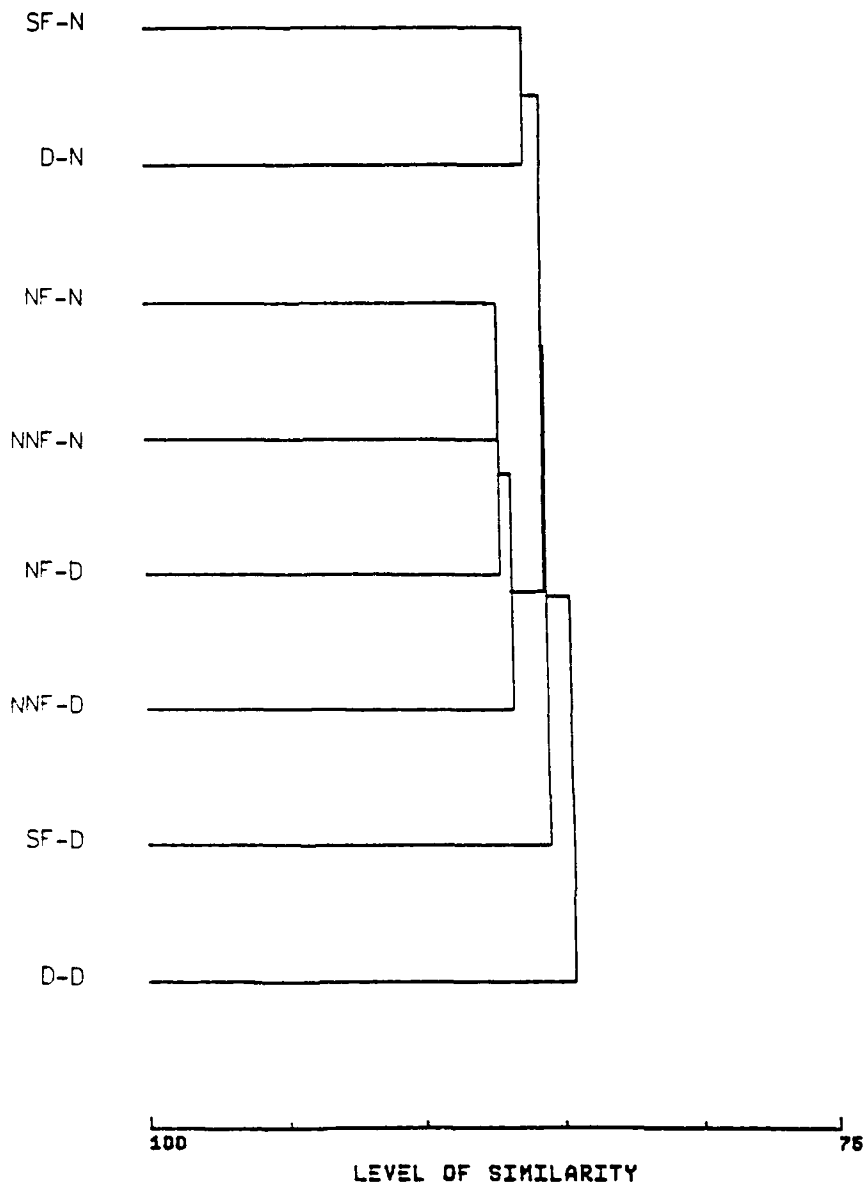


FIGURE 3.2-28 Q-MODE CLUSTER ANALYSIS OF GULFPORT, 6-WEEK POST-DISPOSAL, FISHERIES COLLECTION PERIODS.



NNF-Reference
NF-North Fringe
D-Disposal
SF-South Fringe

D-Day
N-Night

FIGURE 3.2-29 Q-MODE CLUSTER ANALYSIS OF GULFPORT, 20-WEEK POST-DISPOSAL, FISHERIES COLLECTION PERIODS.

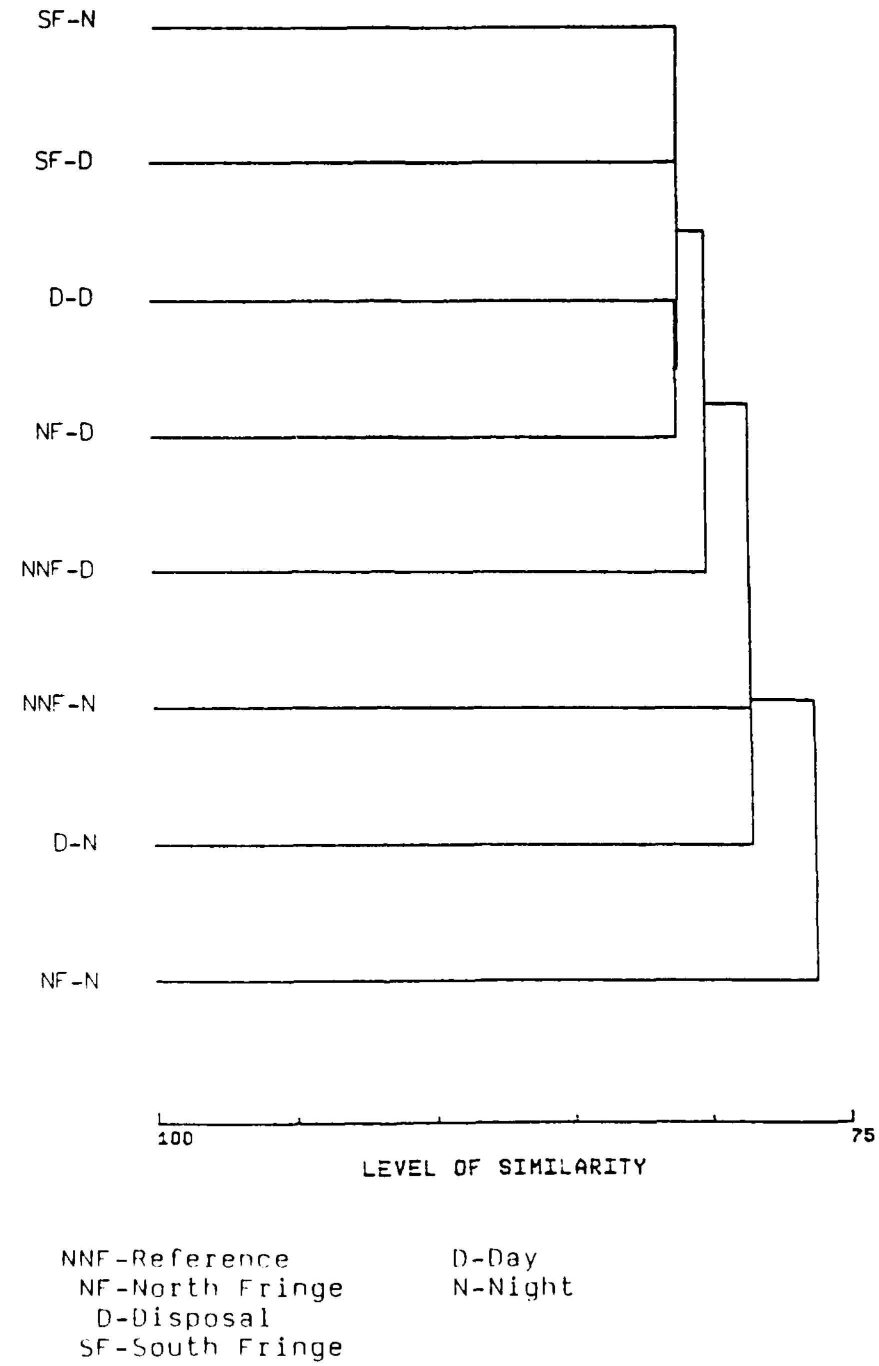


FIGURE 3.2-30 Q-MODE CLUSTER ANALYSIS OF GULFPORT, 52-WEEK POST-DISPOSAL, FISHERIES COLLECTION PERIODS.

Table 3.3-10. Abundance, by treatment area both day and night, of all fisheries organisms collected during the Gulfport study.

	December									January87							February										
	Day				Night					Day				Night			Day				Night				Day		
(G-mode designations)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Taxa	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D
1. _Anchoa hepsetus_																									3		1
2. _Anchoa mitchilli_	52	69	109	119	52	91	61	61	91	15	41	60	53	11	40	15	114	99	111	179	142	126	136	142	221	259	220
3. _Ancylopsetta quadroceliata_																	1										
4. _Archosargus probatocephalus_																						1					
5. _Arius felis_										1							1				4	1	6	3	606	523	303
6. _Bairdiella chrysoura_			2																		1				2	6	1
7. _Brevoortia patronus_	5				1												50	7	18	3	15	63	26	17		1	
8. _Chilomycterus schoepfi_																			1								
9. _Chloroscombrus chrysurus_																									2		1
10. _Citharichthys spilopterus_					1																					1	1
11. _Cynoscion arenarius_												1	1			2	2	2	2	1		1		1	6	3	7
12. _Cynoscion nebulosus_													1				1							1			
13. _Dasyatis sabina_								1									2				1	1	1	2	2		
14. _Dorosoma petenense_																	12	17	6	2	6	5		1	62	49	9
15. _Etropus crossotus_	2	1	1	2	1	3	3	2	3	3	2	6	1	1	3	8	4	2	1	1	5	2	3	10	8	6	5
16. _Gobionellus hastatus_																								1	1	1	1
17. _Hippocampus erectus_		1			1					1		1		1													
18. _Lagodon rhomboides_																											1
19. _Larimus fasciatus_																									1	1	1
20. _Leiostomus xanthurus_		1																1		1	17	2	2	4	3	4	10
21. _Menticirrhus americanus_												1			1		1	1	2	2	2		3	2	16	5	8
22. _Micropogonias undulatus_	3	4	4		3	5	1	1							1		6	4	5	8	4	5	8	2	110	82	184
23. _Monacanthus hispidus_		1																									
24. _Mugil cephalus_										1																	
25. _Peprilus alepidotus_																			1			1	1				1
26. _Peprilus triacanthus_	2	7	9	6		3		1	15	1	4	1		1			5	2	5	3					19	44	16
27. _Pomatomus saltatrix_																											
28. _Porichthys plectrodon_																											1
29. _Prionotus rubio_																											
30. _Prionotus scitulus_			2					1																			

organisms collected

January87								February								May								January88						
Day				Night				Day				Night				Day				Night				Day			Night			
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF
															3		1	1												
15	41	60	53	11	40	15	114	99	111	179	142	126	136	142	221	259	220	172	171	226	243	221	28	50	70	86	119	79	85	263
							1											1												
												1																		
1							1				4	1	6	3	606	523	303	168	688	644	441	370								
											1				2	6	1	3	5	8	10	5								
							50	7	18	3	15	63	26	17		1		2										1	3	2
									1																					
															2		1													
																1	1		1	1	3	1								
		1	1			2	2	2	2	1		1		1	6	3	7	12	11	5	18	4								
			1				1							1																
							2				1	1	1	2	2						2									
							12	17	6	2	6	5		1	62	49	9	11	26	9	9	9				1		3		1
3	2	6	1	1	3	8	4	2	1	1	5	2	3	10	8	6	5	2	6	8	1	3							1	
														1	1	1	1													
1		1		1																										
																	1													
															1	1	1		3	2										
								1		1	17	2	2	4	3	4	10	5	6	7	10	5								
		1			1		1	1	2	2	2		3	2	16	5	8	1	9		7	2								
					1		6	4	5	8	4	5	8	2	110	82	184	131	158	157	281	148					2	2		1
1																														
									1			1	1				1		1		1	1								
1	4	1		1			5	2	5	3					19	44	16	18	26	11	12	7	17	14	13	11	8	3	2	16
																		1												
																	1	1												
																		1	1			1								

Table 3.3-10. (continued)

	December									January87									February									
	Day				Night					Day				Night					Day				Night				Day	
(Q-mode designations)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	2
Taxa	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	S
31. *Prionotus tribulus*	7	10	6	4	11	14	7	9	12	17	7	9	4	6	4	4	15	23	16	17	17	28	25	10	6	9	20	1
32. *Scomberomorus maculatus*																												
33. *Sphoeroides parvus*	15	12	11	12	19	14	15	15	3	2		1			1	2	17	13	17	21	17	19	19	16	2	1		
34. *Symphurus plagiusa*	2	3	3	3	1	1	7	2	5	1	2	1	2	2	6	2	2		2	1	4	3	2	11			2	
35. *Syngnathus louisianae*				1																				1				
36. *Trichiurus lepturus*							1																		23	12	17	
37. *Trinectes maculatus*																									11	5	3	
38. *Urophycis floridanus*									1						1		3	5	1	5	2	4	7	3				
39. *Callinectes sapidus*	11	10	12	8	11	12	10	10	8	10	7	10	6	9	8	7	6	6	3	4	10	8	11	10	4	4	4	
40. *Libinia dubia*																												
41. *Lolliguncula brevis*	5	4	6	6	5	6	3	6	4	2		1			1	2	1	1		2	1			1	5	7	9	
42. Paguridae	1	1	3			2	1		2	1				3	2		2					1	1		5	3	2	
43. *Panopeus herbstii*																												
44. *Penaeus aztecus*			1			2						1	1			1			2	1	1	3	2	1	11	12	12	
45. *Penaeus setiferus*	10	11	13	12	12	12	12	11	12	12	11	12	11	12	12	10	12	9	10	10	8	9	12	11	4	4	1	
46. Porcellanidae	1	2	2			3	1	4		1	1	1		1		1	1	2			1	2	1				2	
47. *Squilla empusa*	13	6	6	7	10	10	12	10	3	4	3	3	4	5	5	4	6	5	5	5	5	9	8	11	1	2	4	

				January87								February								May								January88				
		Day					Night				Day			Night				Day				Night				Day				Night		
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF
9	12	17	7	9	4	6	4	4	15	23	16	17	17	28	25	10	6	9	20	15	6	8	30	23	1						1	1
																						1										
15	3	2		1			1	2	17	13	17	21	17	19	19	16	2	1			1	1	2		1		1			1	1	2
2	5	1	2	1	2	2	6	2	2		2	1	4	3	2	11			2		3											1
																1																
																	23	12	17	6	10	21	11	2								
																	11	5	3	2	31	13	5	3								
	1						1		3	5	1	5	2	4	7	3														1		
10	8	10	7	10	6	9	8	7	6	6	3	4	10	8	11	10	4	4	4	4	15	12	10	9	1	3	2	2	4	2	2	2
																														1		
6	4	2		1			1	2	1	1		2	1			1	5	7	9	9	5	10	14	8		1		2		4		3
	2	1				3	2		2					1	1		5	3	2	2	2		4	1	1		1	1		3	1	1
																											1					
				1	1			1			2	1	1	3	2	1	11	12	12	9	12	12	15	9		1	1			1	3	
[illegible]	12	12	11	12	11	12	12	10	12	9	10	10	8	9	12	11	4	4	1	4	7	5	4	3	3	3	5	4	6	6	6	6
4		1	1	1		1		1	1	2			1	2	1				2				2									
[illegible]	3	4	3	3	4	5	5	4	6	5	5	5	5	9	8	11	1	2	4	1	9	4	7	8			1	3	1	2	1	3

Table 3.3-11. Abundance, by treatment area both day and night, of fishes collected during the Gulfport study.

	DECEMBER								JANUARY87								FEBRUARY								(			
	DAY				NIGHT				DAY				NIGHT				DAY				NIGHT				DAY			
(Q-mode designations)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	2
Taxa	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	S
1. Anchoa hepsetus																									3		1	
2. Anchoa mitchilli	52	69	109	119	52	91	61	61	91	15	41	60	53	11	40	15	114	99	111	179	142	126	136	142	221	259	220	17
3. Ancylopsetta quadrocellata																	1											
4. Archosargus probatocephalus																						1						
5. Arius felis										1							1				4	1	6	3	606	523	303	18
6. Bairdiella chrysoura			2																		1				2	6	1	
7. Brevoortia patronus	5				1												50	7	18	3	15	63	26	17		1		
8. Chilomycterus schoepfi																			1									
9. Chloroscombrus chrysurus																									2		1	
10. Citharichthys spilopterus					1																					1	1	
11. Cynoscion arenarius												1	1			2	2	2	2	1		1		1	6	3	7	1
12. Cynoscion nebulosus													1				1							1				
13. Dasyatis sabina								1									2				1	1	1	2	2			
14. Dorosoma petenense																	12	17	6	[illegible]	6	[illegible]		1	62	49	9	1
15. Etropus crossotus	2	1	1	2	1	3	3	2	3	3	2	6	1	1	3	2	4	2	1	1	5	2	3	10	8	6	5	
16. Gobionellus hastatus																								1	1	1	1	
17. Hippocampus erectus		1			1					1		1		1														
18. Lagodon rhomboides																											1	
19. Larimus fasciatus																									1	1	1	
20. Leiostomus xanthurus		1																1		1	17	2	2	4	3	4	10	
21. Menticirrhus americanus												1			1		1	1	2	2	2		3	2	16	5	8	
22. Micropogonias undulatus	3	4	4		3	5	1	1							1		6	4	5	8	4	5	8	2	110	82	184	13
23. Monacanthus hispidus		1																										
24. Mugil cephalus										1																		
25. Peprilus alepidotus																			1			1	1				1	
26. Peprilus triacanthus	2	7	9	6		3		1	15	1	4	1		1			5	2	5	3					19	44	16	1
27. Pomatomus saltatrix																												
28. Porichthys plectrodon																											1	
29. Prionotus rubio																												
30. Prionotus scitulus			2					1																				
31. Prionotus tribulus	7	10	6	4	11	14	7	9	12	17	7	9	4	6	4	4	15	23	16	17	17	28	25	10	6	9	20	1
32. Scomberomorus maculatus																												
33. Sphoeroides parvus	15	12	11	12	19	14	15	15	3	2		1			1	2	17	13	17	21	17	19	19	16	2	1		
34. Symphurus plagiusa	2	3	3	3	1	1	7	2	5	1	2	1	2	2	6	2	2		2	1	4	3	2	11			2	
35. Syngnathus louisianae				1																				1				
36. Trichiurus lepturus							1																		23	12	17	
37. Trinectes maculatus																									11	5	3	
38. Urophycis floridanus									1						1		3	5	1	5	2	4	7	3				

ollected during the Gulfport study.

9 NNF	10 NF	11 D	12 SF	13 NNF	14 NF	15 D	16 SF	17 NNF	18 NF	19 D	20 SF	21 NNF	22 NF	23 D	24 SF	25 NNF	26 NF	27 D	28 SF	29 NNF	30 NF	31 D	32 SF	33 NNF	34 NF	35 D	36 SF	37 NNF	38 NF	39 D	40 SF
JANUARY87								FEBRUARY								MAY								January88							
DAY				NIGHT				DAY				NIGHT				DAY				NIGHT				DAY				NIGHT			
																3		1	1												
91	15	41	60	53	11	40	15	114	99	111	179	142	126	136	142	221	259	220	172	171	226	243	221	28	50	70	86	119	79	85	263
								1											1												
													1																		
	1							1				4	1	6	3	606	523	303	188	688	644	441	370								
												1				2	6	1	3	5	8	10	5								
								50	7	18	3	15	63	26	17		1		2										1	3	2
										1																					
																2		1													
																	1	1		1	1	3	1								
			1	1			2	2	2	2	1		1		1	6	3	7	12	11	5	18	4								
				1				1							1																
								2				1	1	1	2	2						2									
								12	17	6	2	6	5		1	62	49	9	11	26	9	9	9				1		3		1
3	3	2	6	1	1	3	8	4	2	1	1	5	2	3	10	8	6	5	2	6	8	1	3							1	
															1	1	1	1													
	1		1		1																										
																		1													
																1	1	1		3	2										
									1		1	17	2	2	4	3	4	10	5	6	7	10	5								
			1			1		1	1	2	2	2		3	2	16	5	8	1	9		7	2								
						1		6	4	5	8	4	5	8	2	110	82	184	131	158	157	281	148					2	2		1
	1																														
										1			1	1				1		1		1	1								
15	1	4	1		1			5	2	5	3					19	44	16	18	26	11	12	7	17	14	13	11	8	3	2	16
																			1												
																		1	1												
																			1	1			1								
12	17	7	9	4	6	4	4	15	23	16	17	17	28	25	10	6	9	20	15	6	8	30	23	1						1	1
																					1										
3	2		1			1	2	17	13	17	21	17	19	19	16	2	1			1	1	2		1		1			1	1	2
5	1	2	1	2	2	6	2	2		2	1	4	3	2	11			2		3											1
															1																
																23	12	17	6	10	21	11	2								
																11	5	3	2	31	13	5	3								
1						1		3	5	1	5	2	4	7	3														1		

Table 3.3-12. Abundance, by treatment area both day and night, of invertebrates collected during the Gulfport fisheries study.

(Q-mode designations)	December									January86								February										May
	Day					Night				Day				Night				Day				Night				Day		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Taxa	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF
1. _Callinectes sapidus_	11	10	12	8	11	12	10	10	8	10	7	10	6	9	8	7	6	6	3	4	10	8	11	10	4	4	4	4
2. _Libinia dubia_																												
3. _Lolliguncula brevis_	5	4	6	6	5	6	3	6	4	2		1			1	2	1	1		2	1			1	5	7	9	9
4. Paguridae	1	1	3			2	1		2	1				3	2		2					1	1		5	3	2	2
5. _Panopeus herbstii_																												
6. _Penaeus aztecus_			1			2						1	1			1			2	1	1	3	2	1	11	12	12	9
7. _Penaeus setiferus_	10	11	13	12	12	12	12	11	12	12	11	12	11	12	12	10	12	9	10	10	8	9	12	11	4	4	1	4
8. Porcellanidae	1	2	2			3	1	4		1	1	1		1		1	1	2			1	2	1				2	
9. _Squilla empusa_	13	6	6	7	10	10	12	10	3	4	3	3	4	5	5	4	6	5	5	5	5	9	8	11	1	2	4	1

:es collected during the Gulfport fisheries study.

January86									Feoruary							
Day					Night				Day				Night			
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF
8	10	7	10	6	9	8	7	6	6	3	4	10	8	11	10	4
4	2		1			1	2	1	1		2	1			1	5
2	1				3	2		2					1	1		5
			1	1			1			2	1	1	3	2	1	11
12	12	11	12	11	12	12	10	12	9	10	10	8	9	12	11	4
	1	1	1		1		1	1	2			1	2	1		
3	4	3	3	4	5	5	4	6	5	5	5	5	9	8	11	1

May								January87							
Day				Night				Day				Night			
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	NNF	NF	D	SF	
4	4	4	15	12	10	9	1	3	2	2	4	2	2	2	
												1			
7	9	9	5	10	14	8		1		2		4		3	
3	2	2	2		4	1	1		1	1		3	1	1	
									1						
12	12	9	12	12	15	9		1	1			1	3		
4	1	4	7	5	4	3	3	3	5	4	6	6	6	6	
	2				2										
2	4	1	9	4	7	8			1	3	1	2	1	3	

Table 3.3-13. Diurnal abundance, by area, for fisheries organisms collected during the 2 week pre-disposal field effort.

	Day				Night			
(Q-mode designations) Taxa	1 NNF	2 NF	3 D	4 SF	5 NNF	6 NF	7 D	8 SF
1. *Anchoa mitchilli*	52	69	109	119	52	91	61	61
2. *Bairdiella chrysoura*			2					
3. *Brevoortia patronus*	5				1			
4. *Citharichthys spilopterus*					1			
5. *Dasyatis sabina*								1
6. *Etropus crossotus*	2	1	1	2	1	3	3	2
7. *Hippocampus erectus*		1			1			
8. *Leiostomus xanthurus*		1						
9. *Micropogonias undulatus*	3	4	4		3	5	1	1
10. *Monacanthus hispidus*		1						
11. *Peprilus triacanthus*	2	7	9	6		3		1
12. *Prionotus scitulus*			2					1
13. *Prionotus tribulus*	7	10	6	4	11	14	7	9
14. *Sphoeroides parvus*	15	12	11	12	19	14	15	15
15. *Symphurus plagiusa*	2	3	3	3	1	1	7	2
16. *Syngnathus louisianae*				1				
17. *Trichiurus lepturus*							1	
18. *Callinectes sapidus*	11	10	12	8	11	12	10	10
19. *Lolliguncula brevis*	5	4	6	6	5	6	3	6
20. Paguridae	1	1	3			2	1	
21. *Penaeus aztecus*			1			2		
22. *Penaeus setiferus*	10	11	13	12	12	12	12	11
23. Porcellanidae	1	2	2			3	1	4
24. *Squilla empusa*	13	6	6	7	10	10	12	10

Table 3.3-14. Diurnal abundance, by area, for fisheries organisms collected during the 2-week post-disposal field effort.

			Day				Night	
(Q-mode designations) Taxa	1 NNF	2 NF	3 D	4 SF	5 NNF	6 NF	7 D	8 SF
1. *Anchoa mitchilli*	91	15	41	60	53	11	40	15
2. *Arius felis*		1						
3. *Cynoscion arenarius*				1	1			2
4. *Cynoscion nebulosus*					1			
5. *Etropus crossotus*	3	3	2	6	1	1	3	8
6. *Hippocampus erectus*		1		1		1		
7. *Menticirrhus americanus*				1			1	
8. *Micropogonias undulatus*							1	
9. *Mugil cephalus*		1						
10. *Peprilus triacanthus*	15	1	4	1		1		
11. *Prionotus tribulus*	12	17	7	9	4	6	4	4
12. *Sphoeroides parvus*	3	2		1			1	2
13. *Symphurus plagiusa*	5	1	2	1	2	2	6	2
14. *Urophycis floridanus*	1						1	
15. *Callinectes sapidus*	8	10	7	10	6	9	8	7
16. *Lolliguncula brevis*	4	2		1			1	2
17. Paguridae	2	1				3	2	
18. *Penaeus aztecus*				1	1			1
19. *Penaeus setiferus*	12	12	11	12	11	12	12	10
20. Porcellanidae		1	1	1		1		1
21. *Squilla empusa*	3	4	3	3	4	5	5	4

Table 3.3-15. Diurnal abundance, by area, for fisheries organisms collected during the 6-week post-disposal field effort.

	Day				Night			
(Q-mode designations) Taxa	1 NNF	2 NF	3 D	4 SF	5 NNF	6 NF	7 D	8 SF
1. Anchoa mitchilli	114	99	111	179	142	126	136	142
2. Ancylopsetta quadrocellata	1							
3. Archosargus probatocephalus						1		
4. Arius felis	1				4	1	6	3
5. Bairdiella chrysoura					1			
6. Brevoortia patronus	50	7	18	3	15	63	26	17
7. Chilomycterus schoepfi			1					
8. Cynoscion arenarius	2	2	2	1		1		1
9. Cynoscion nebulosus	1							1
10. Dasyatis sabina	2				1	1	1	2
11. Dorosoma petenense	12	17	6	2	6	5		1
12. Etropus crossotus	4	2	1	1	5	2	3	10
13. Gobionellus hastatus								1
14. Leiostomus xanthurus		1		1	17	2	2	4
15. Menticirrhus americanus	1	1	2	2	2		3	2
16. Micropogonias undulatus	6	4	5	8	4	5	8	2
17. Peprilus alepidotus			1			1	1	
18. Peprilus triacanthus	5	2	5	3				
19. Prionotus tribulus	15	23	16	17	17	28	25	10
20. Sphoeroides parvus	17	13	17	21	17	19	19	16
21. Symphurus plagiusa	2		2	1	4	3	2	11
22. Syngnathus louisianae								1
23. Urophycis floridanus	3	5	1	5	2	4	7	3
24. Callinectes sapidus	6	6	3	4	10	8	11	10
25. Lolliguncula brevis	1	1		2	1			1
26. Paguridae	2					1	1	
27. Penaeus aztecus			2	1	1	3	2	1
28. Penaeus setiferus	12	9	10	10	8	9	12	11
29. Porcellanidae	1	2			1	2	1	
30. Squilla empusa	6	5	5	5	5	9	8	11

Table 3.3-16. Diurnal abundance, by area, for fisheries organisms collected during the 20-week post-disposal field effort.

(Q-mode designations)	Day				Night			
Taxa	1 NNF	2 NF	3 D	4 SF	5 NNF	6 NF	7 D	8 SF
1. Anchoa hepsetus	3		1	1				
2. Anchoa mitchilli	221	259	220	172	171	226	243	221
3. Ancylopsetta quadrocellata				1				
4. Arius felis	606	523	303	188	688	644	441	370
5. Bairdiella chrysoura	2	6	1	3	5	8	10	5
6. Brevoortia patronus		1		2				
7. Chloroscombrus chrysurus	2		1					
8. Citharichthys spilopterus		1	1		1	1	3	1
9. Cynoscion arenarius	6	3	7	12	11	5	18	4
10. Dasyatis sabina	2						2	
11. Dorosoma petenense	62	49	9	11	26	9	9	9
12. Etropus crossotus	8	6	5	2	6	8	1	3
13. Gobionellus hastatus	1	1	1					
14. Lagodon rhomboides			1					
15. Larimus fasciatus	1	1	1		3	2		
16. Leiostomus xanthurus	3	4	10	5	6	7	10	5
17. Menticirrhus americanus	16	5	8	1	9		7	2
18. Micropogonias undulatus	110	82	184	131	158	157	281	148
19. Peprilus alepidotus			1		1		1	1
20. Peprilus triacanthus	19	44	16	18	26	11	12	7
21. Pomatomus saltatrix				1				
22. Porichthys plectrodon			1	1				
23. Prionotus rubio				1	1			1
24. Prionotus tribulus	6	9	20	15	6	8	30	23
25. Scomberomorus maculatus						1		
26. Sphoeroides parvus	2	1			1	1	2	
27. Symphurus plagiusa			2		3			
28. Trichiurus lepturus	23	12	17	6	10	21	11	2
29. Trinectes maculatus	11	5	3	2	31	13	5	3
30. Callinectes sapidus	4	4	4	4	15	12	10	9
31. Lolliguncula brevis	5	7	9	9	5	10	14	8
32. Paguridae	5	3	2	2	2		4	1
33. Penaeus aztecus	11	12	12	9	12	12	15	9
34. Penaeus setiferus	4	4	1	4	7	5	4	3
35. Porcellanidae			2				2	
36. Squilla empusa	1	2	4	1	9	4	7	8

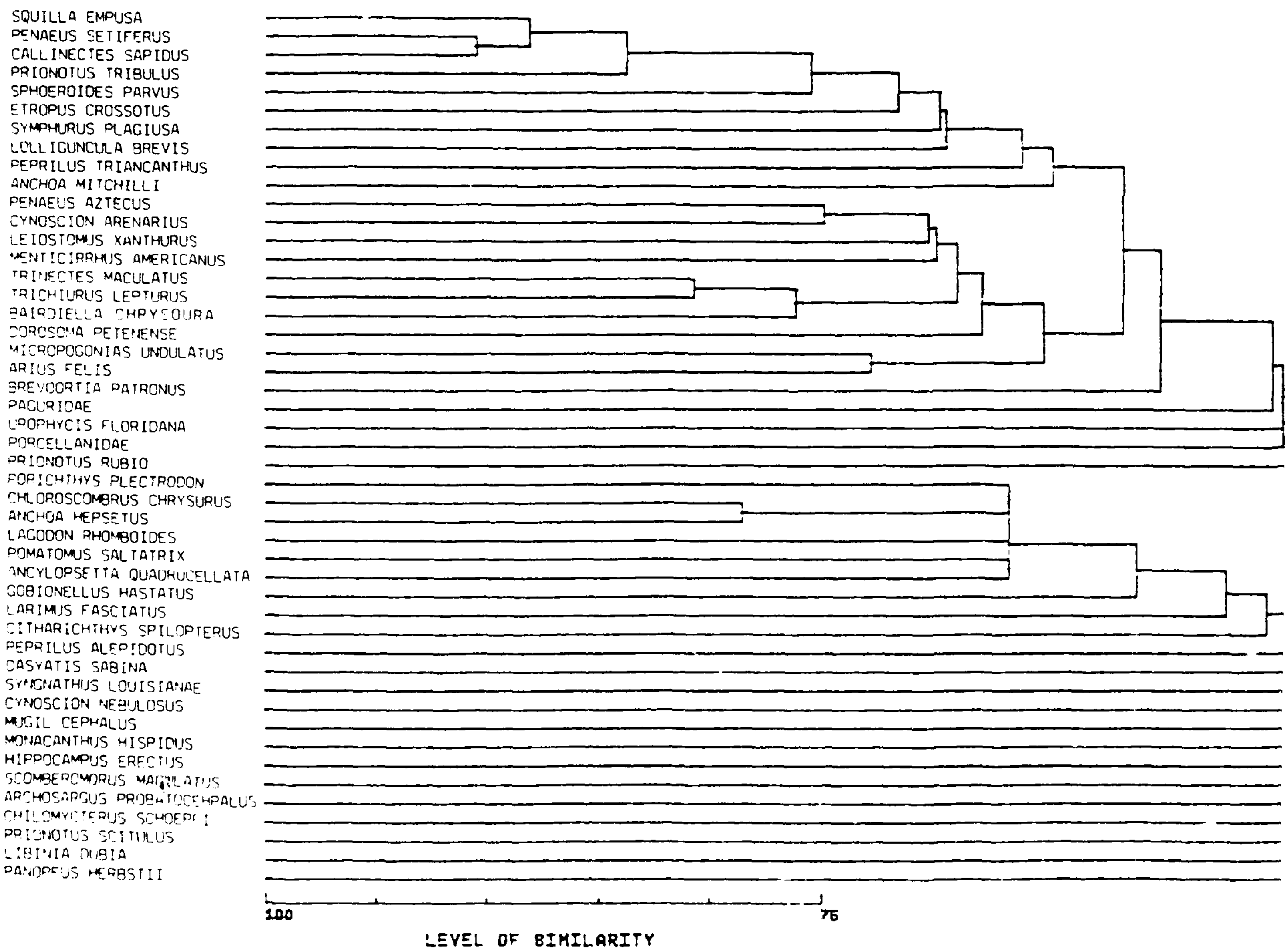
Table 3.3-17. Diurnal abundance, by area, for fisheries organisms collected during the 52 week pre-disposal field effort.

(Q-mode designations) Taxa	Day				Night			
	1 NNF	2 NF	3 D	4 SF	5 NNF	6 NF	7 D	8 SF
1. *Anchoa mitchilli*	28	50	70	86	119	79	85	263
2. *Brevoortia patronus*						1	3	2
3. *Dorosoma petenense*				1		3		1
4. *Etropus crossotus*							1	
5. *Micropogonias undulatus*					2	2		1
6. *Peprilus triacanthus*	17	14	13	11	8	3	2	16
7. *Prionotus tribulus*	1						1	1
8. *Sphoeroides parvus*	1		1			1	1	2
9. *Symphurus plagiusa*								1
10. *Urophycis floridanus*						1		
11. *Callinectes sapidus*	1	3	2	2	4	2	2	2
12. *Libinia dubia*						1		
13. *Lolliguncula brevis*		1		2		4		3
14. Paguridae	1		1	1		3	1	1
15. *Panopeus herbstii*			1					
16. *Penaeus aztecus*		1	1			1	3	
17. *Penaeus setiferus*	3	3	5	4	6	6	6	6
19. *Squilla empusa*			1	3	1	2	1	3

Figure 3.2-26 (2-week pre-disposal) showed no distinct diel or spatial separation. The lack of a diel separation was again apparent during the 2-week post-disposal sampling period (Figure 3.2-27), but the disposal area sampling period linked more closely to the northern or reference sampling period than to the southern sampling period.

Figure 3.2-28 shows a diel separation during the 6-week post-disposal sampling period, but no clear spatial pattern. This is the only direct linkage of a disposal area collection to a southern fringe area collection. During the 20-week post-disposal sampling period (Figure 3.2-29), a close linkage between the disposal and southern fringe area night collection periods is present. The 52-week post-disposal monitoring period again showed a diel separation with the daytime collection periods forming a grouping (Figure 3.2-30).

The r-mode cluster analyses, presented in Figures 3.2-31 through 3.2-38, were also developed utilizing the Bray-Curtis resemblance measure. This analysis presents a series of similarity indices for all fisheries organisms, vertebrates only, invertebrates only and by monitoring period for all species collected and presented in Tables 3.2-10 through 3.2-17. Figure 3.2-29 shows the r-mode cluster analysis for all major fisheries taxa, both vertebrate and invertebrate. Three major groupings were present. The first grouping represents a series of species, both vertebrate and invertebrate, that showed a ubiquitous temporal distribution over the monitoring periods Table 3.2-10. This grouping includes Penaeus setiferus, (white shrimp), Etropus crossotus, (fringed flounder), Anchoa mitchilli, Prionotus tribulus, (bighead sea robin), Callinectes sapidus, (blue crab), and several others. Four of the five numerically dominant invertebrates occurred in this grouping. The next grouping represents species showing a high occurrence during the 6 and 20-week post-disposal monitoring periods. This grouping includes Penaeus aztecus, (brown shrimp), Leiostomus xanthurus, (spot), Micropogonias undulatus, (croaker), Arius felis and six other species. The third grouping includes species having a low occurrence during the 6 and 20-week post-disposal monitoring periods and absent during other monitoring periods. These include Anchoa hepsetus, (striped anchovy), Chloroscombrus



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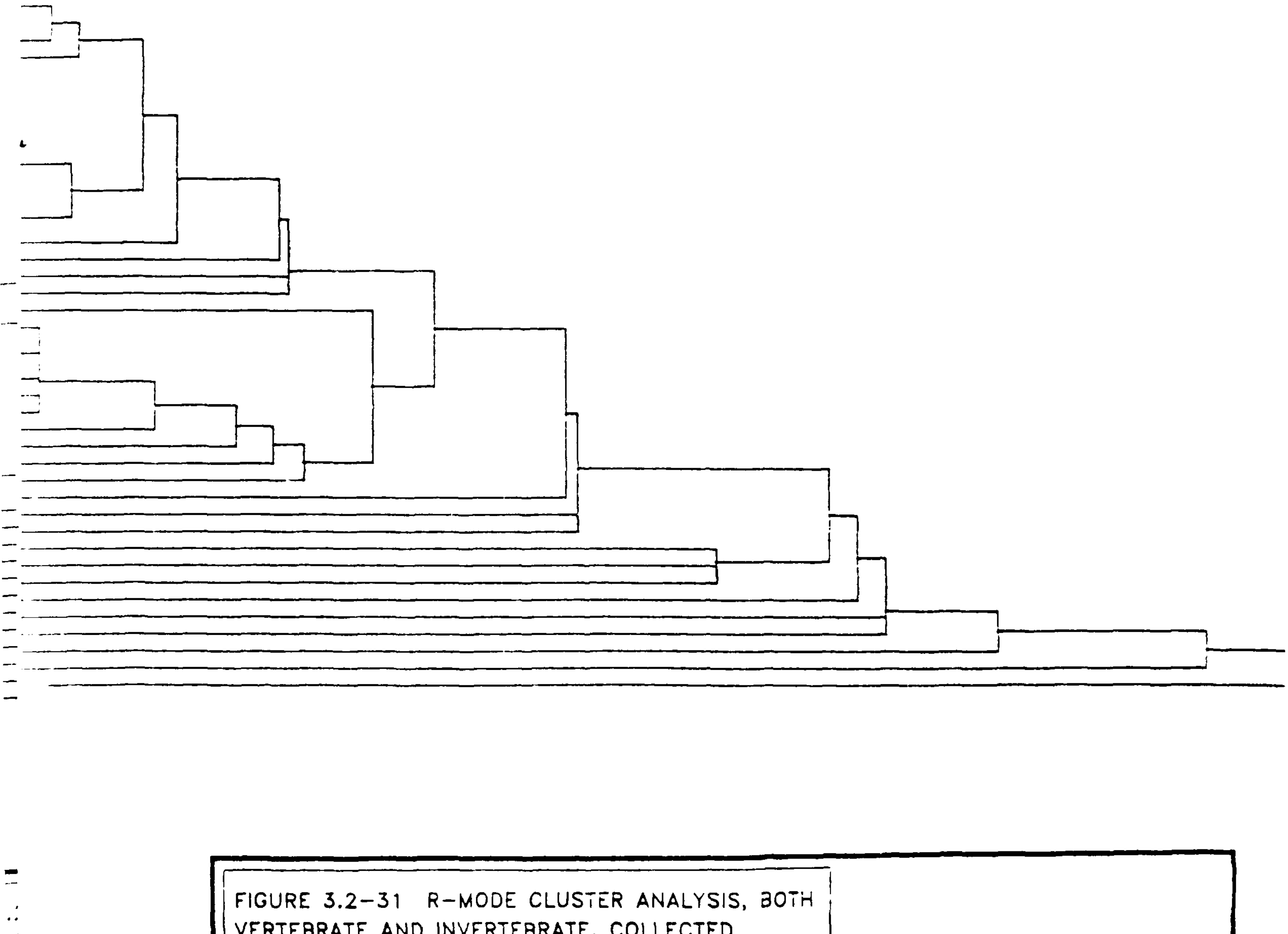
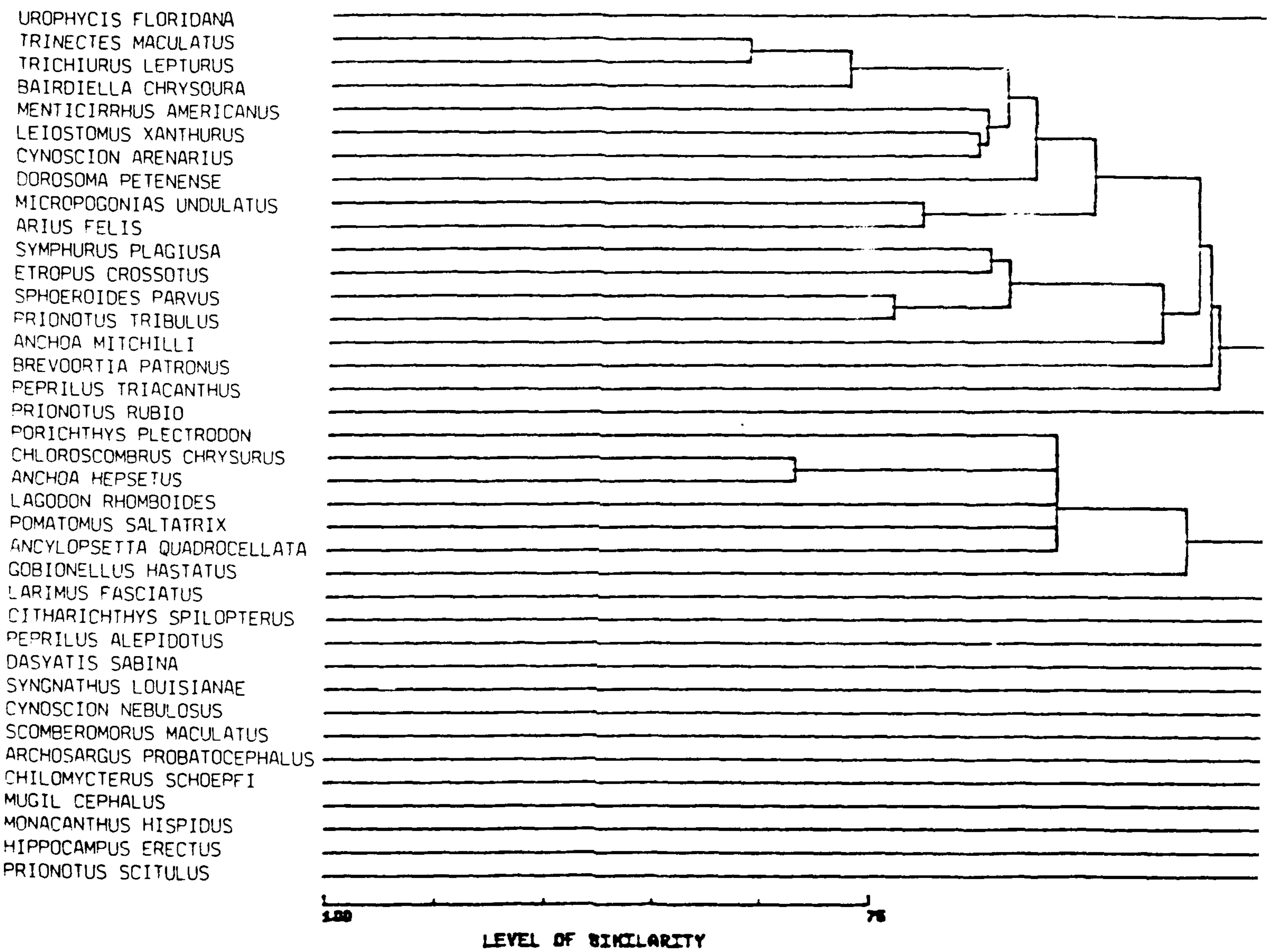


FIGURE 3.2-31 R-MODE CLUSTER ANALYSIS, BOTH VERTEBRATE AND INVERTEBRATE, COLLECTED DURING GULFPORT FISHERIES STUDIES.


UROPHYCIS FLORIDANA
TRINECTES MACULATUS
TRICHIURUS LEPTURUS
BAIRDIELLA CHRYSOURA
MENTICIRRHUS AMERICANUS
LEIOSTOMUS XANTHURUS
CYNOSCION ARENARIUS
DOROSOMA PETENENSE
MICROPOGONIAS UNDULATUS
ARIUS FELIS
SYMPHURUS PLAGIUSA
ETROPUS CROSSOTUS
SPHOEROIDES PARVUS
PRIONOTUS TRIBULUS
ANCHOA MITCHILLI
BREVOORTIA PATRONUS
PEPRILUS TRIACANTHUS
PRIONOTUS RUBIO
PORICHTHYS PLECTRODON
CHLOROSCOMBRUS CHRYSURUS
ANCHOA HEPSETUS
LAGODON RHOMBOIDES
POMATOMUS SALTATRIX
ANCYLOPSETTA QUADROCELLATA
GOBIONELLUS HASTATUS
LARIMUS FASCIATUS
CITHARICHTHYS SPILOPTERUS
PEPRILUS ALEPIDOTUS
DASYATIS SABINA
SYNGNATHUS LOUISIANAE
CYNOSCION NEBULOSUS
SCOMBEROMORUS MACULATUS
ARCHOSARGUS PROBATOCEPHALUS
CHILOMYCTERUS SCHOEPFI
MUGIL CEPHALUS
MONACANTHUS HISPIDUS
HIPPOCAMPUS ERECTUS
PRIONOTUS SCITULUS
100
75
LEVEL OF SIMILARITY

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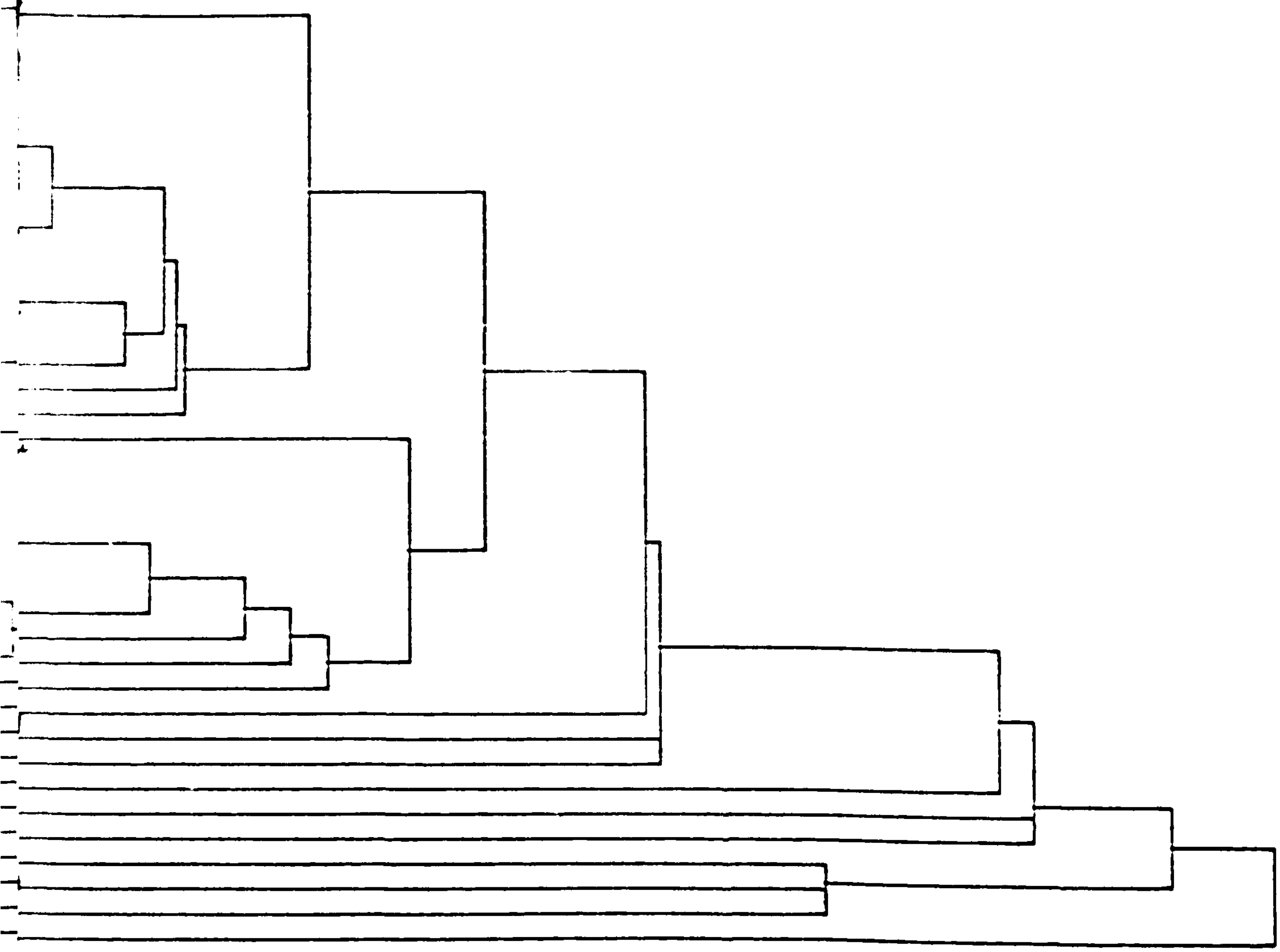


FIGURE 3.2-32 R-MODE CLUSTER ANALYSIS OF THE MAJOR VERTEBRATE TAXA COLLECTED DURING THE GULFPORT FISHERIES STUDIES.

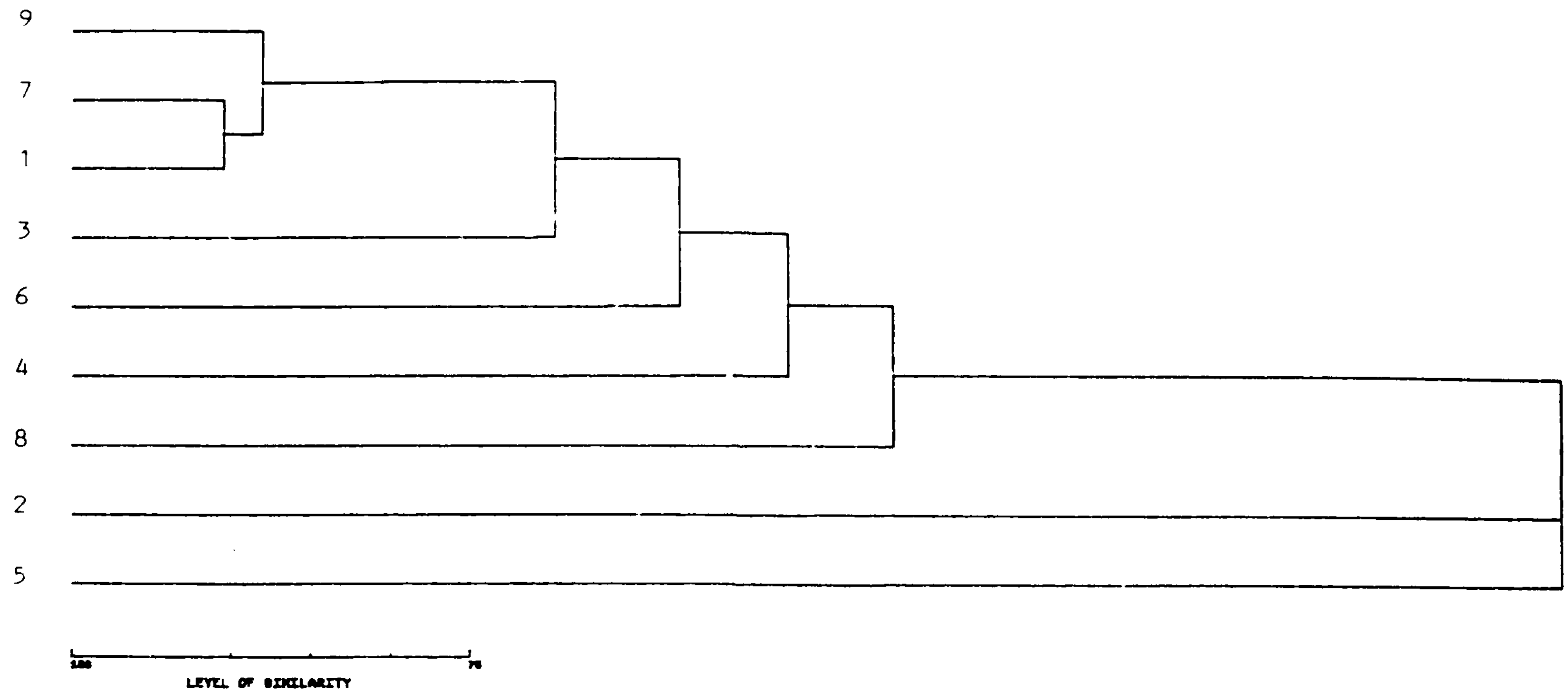


FIGURE 3.2–33 R–MODE CLUSTER ANALYSIS OF MAJOR INVERTEBRATE TAXA COLLECTED DURING GULFPORT FISHERIES TASK.

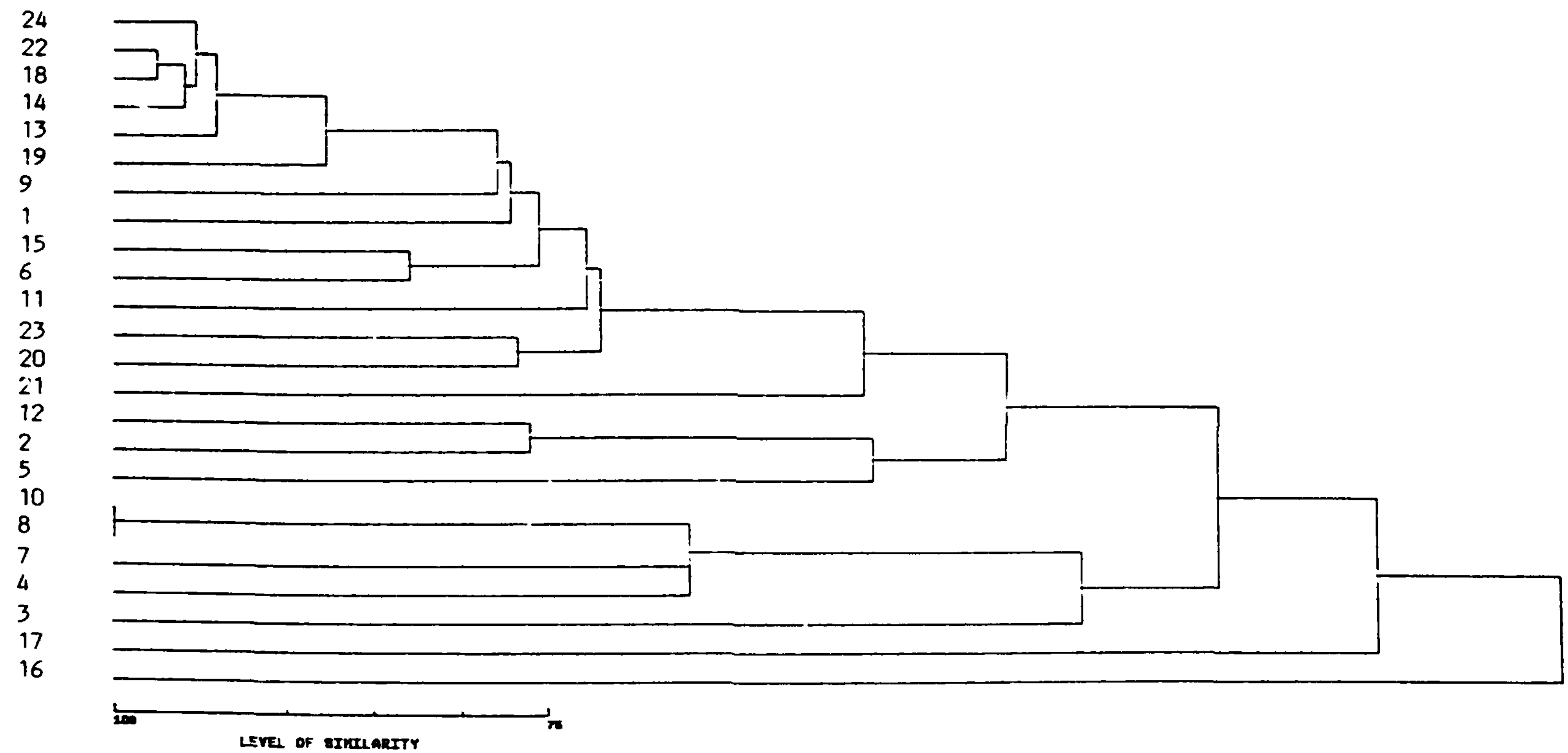


FIGURE 3.2–34 R–MODE CLUSTER ANALYSIS OF MAJOR TAXA COLLECTED DURING 2–WEEK PRE–DISPOSAL FISHERIES TASK.

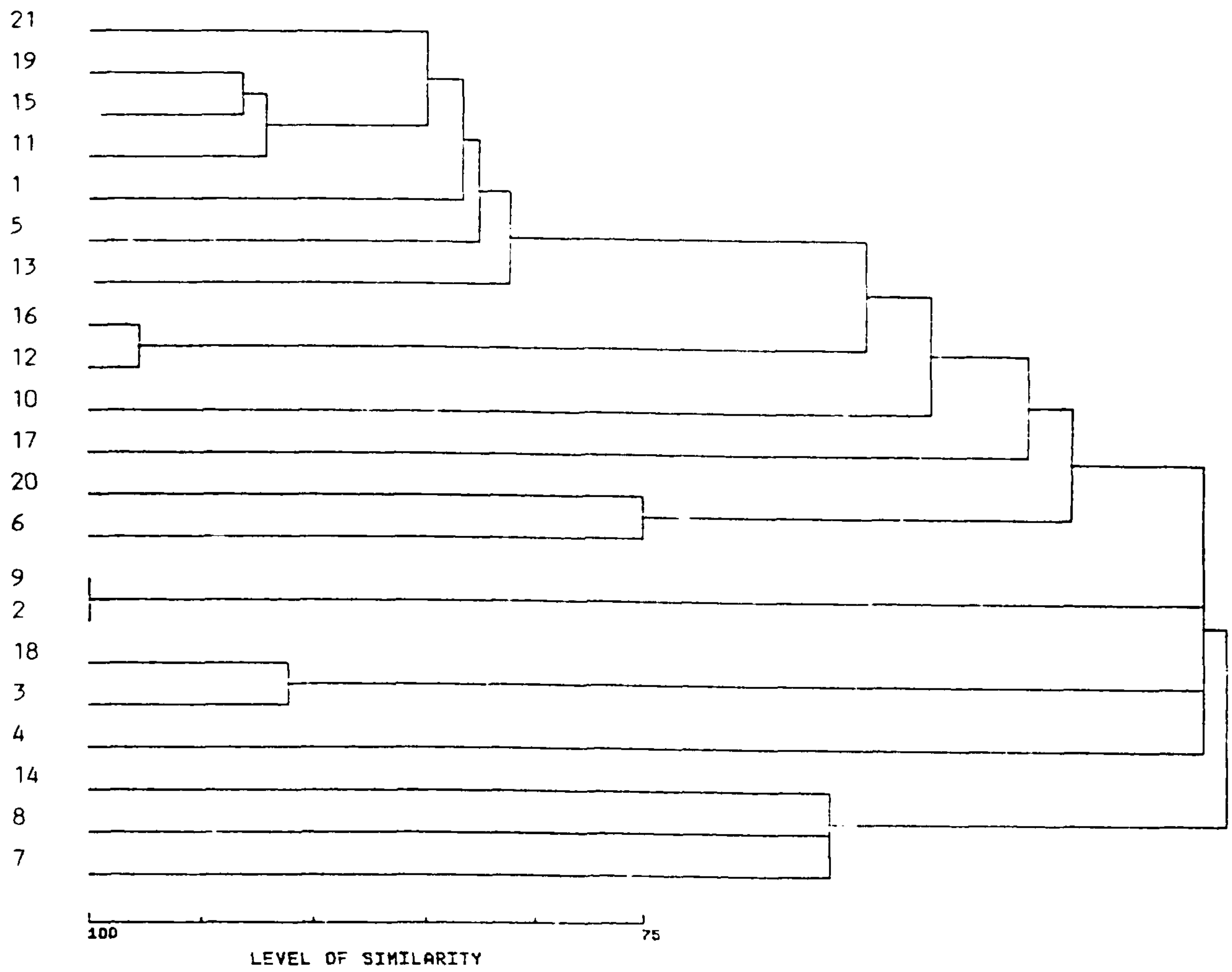


FIGURE 3.2–35 R–MODE CLUSTER ANALYSIS OF MAJOR TAXA COLLECTED DURING 2–WEEK POST–DISPOSAL FISHERIES TASK.

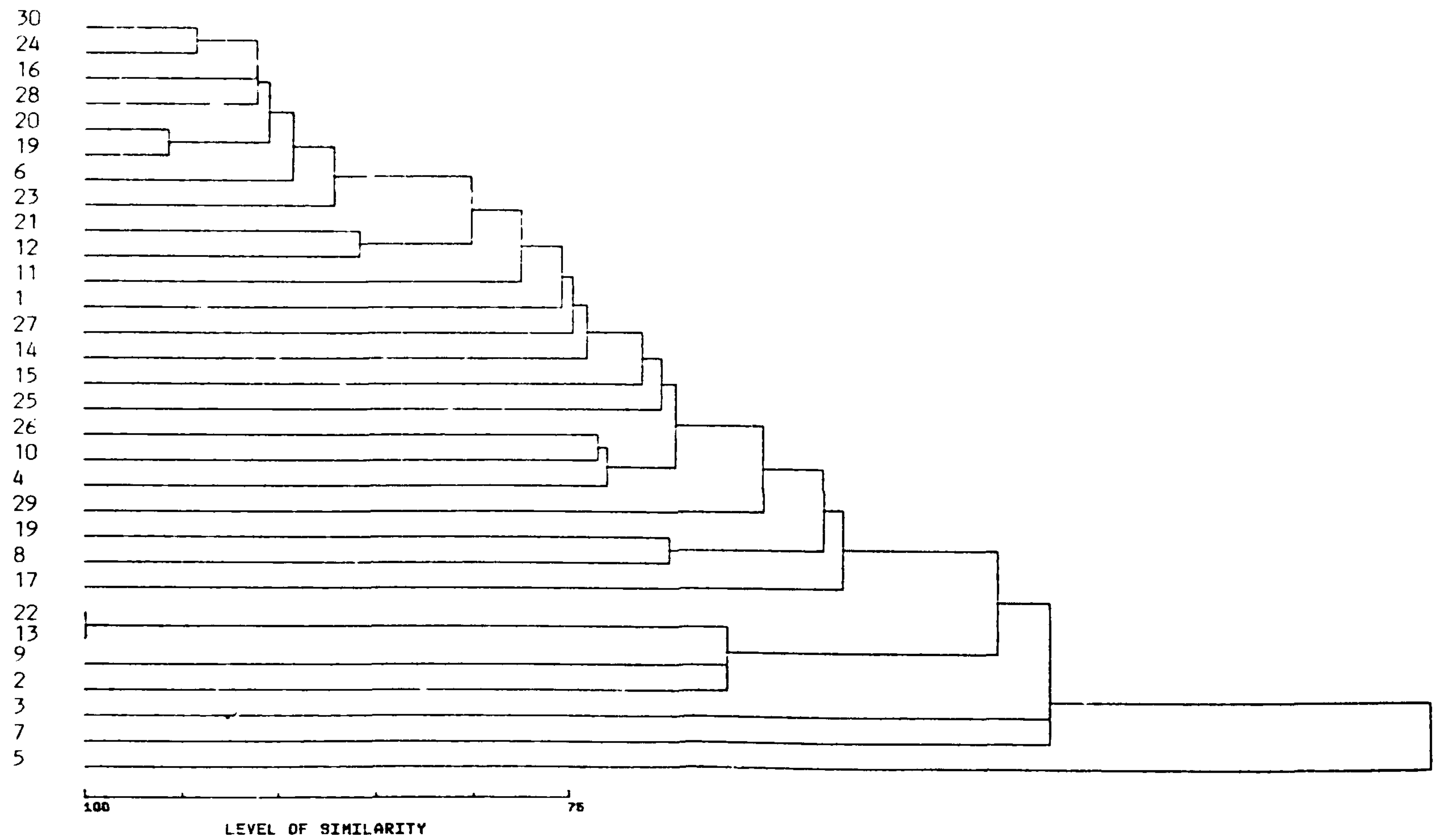


FIGURE 3.2-36 R-MODE CLUSTER ANALYSIS OF MAJOR TAXA COLLECTED DURING 6-WEEK POST-DISPOSAL FISHERIES TASK.

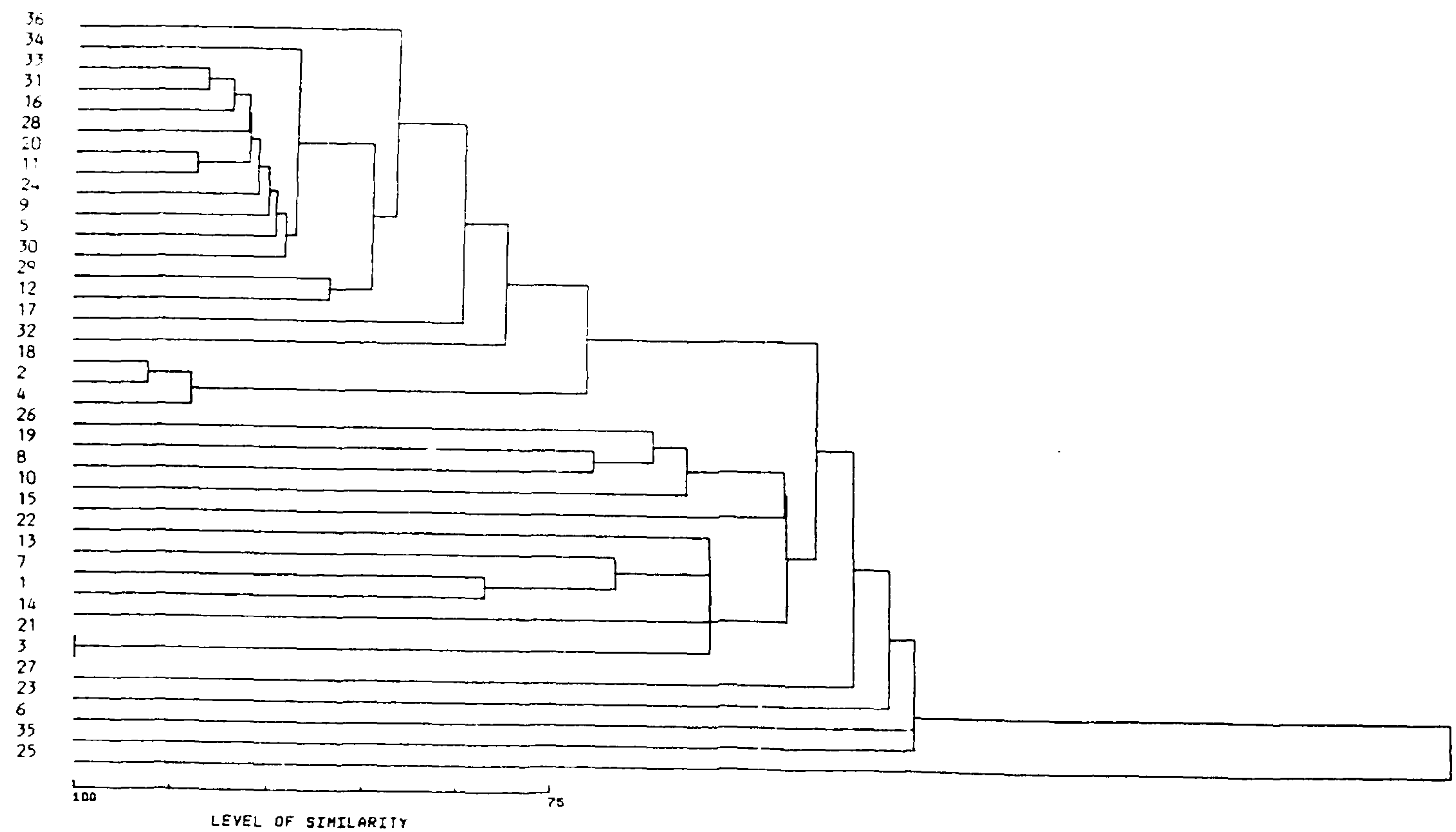


FIGURE 3.2-37 R-MODE CLUSTER ANALYSIS OF MAJOR TAXA COLLECTED DURING 20-WEEK POST-DISPOSAL FISHERIES TASK.

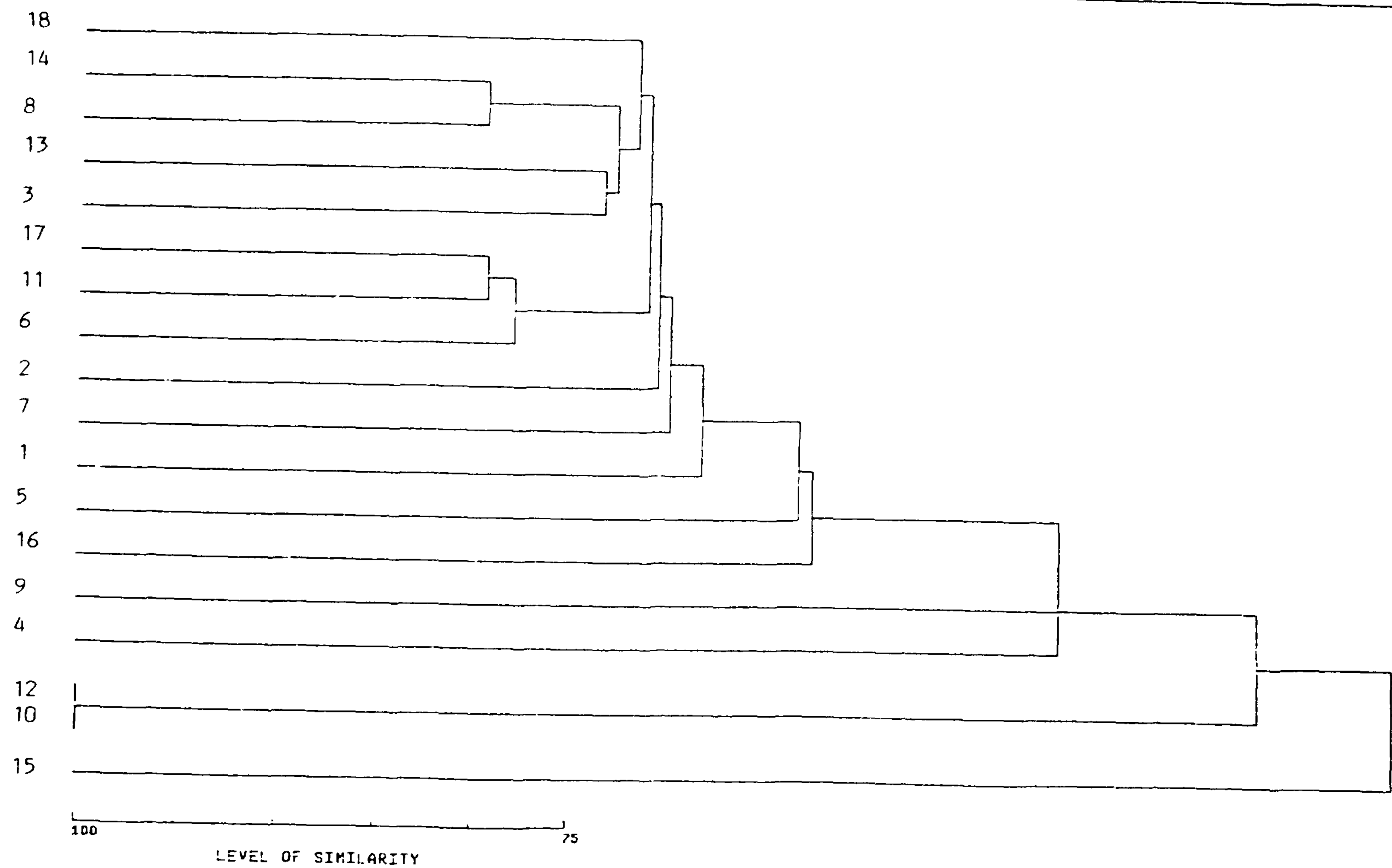


FIGURE 3.2-38 R-MODE CLUSTER ANALYSIS OF MAJOR TAXA COLLECTED DURING 52-WEEK POST-DISPOSAL FISHERIES TASK.

chrysurus, (Atlantic bumper), Gobionellus hastatus, (sharptailed goby), and seven other species.

Figure 3.2-32, representing the r-mode cluster analysis of the major vertebrate taxa was divided into two major groupings. These groupings were clearly separated on the basis of overall abundance with one grouping consisting of the 17 numerically dominant vertebrate species. The other grouping contained species with lower abundances, and their occurrences were during the 6 and 20-week post-disposal monitoring periods. The r-mode cluster analysis of the dominant invertebrate species is presented in Figure 3.2-33. The three most numerous species Squilla empusa, (mantis shrimp), Penaeus setiferus and Callinectes sapidus form a tight cluster with the others linking on in order of decreasing abundance.

Figure 3.2-34, representing the r-mode cluster analysis for the 2-week pre-disposal monitoring period showed an obvious demersal species assemblage with five mud-bottom dwellers forming a tight cluster. These five species, Squilla empusa, Penaeus setiferus, Callinectes sapidus, Prionotus tribulus, and Sphoeroides parvus, (least puffer), also display a fairly even distribution over the collection periods and areas, showing no clear spatial or diel preference. This grouping was part of a larger assemblage of species which displayed no clear spatial or diel distribution. A second small cluster was composed of five species Leiostomus xanthurus, Brevoortia patronus, (Gulf menhaden), Monacanthus hispidus, (planehead filefish), Citherichthys spilopterus, (Bay whiff) and Hippocampus erectus, (lined seahorse), which occurred only in the disposal and southern fringe sampling areas.

The r-mode cluster analysis for the 2-week post-disposal monitoring period is presented in Figure 3.2-35. This figure again shows a tight grouping of mud-bottom dwellers containing seven species and being part of a larger grouping having no clear spatial or diel separation, but a rather even distribution over the collection periods. This trend continues in Figure 3.2-36 that represents the r-mode cluster analysis for the 6-week post-disposal monitoring period. Eight species form a grouping of mud-bottom dwellers having no definite spatial or diel pattern to their occurrence.

The 20-week post-disposal monitoring period shows a different pattern with the three numerically dominant vertebrates Micropogonias undulatus, Anchoa mitchilli and Arius felis forming a tight grouping. This tight grouping links to another larger grouping of species with varying abundances and ubiquitous distributions with no diel patterns. The Q-mode figure for this monitoring program (Figure 3.2-29), showed a linkage between the night collections of the disposal and southern fringe sampling areas.

The 52-week post-disposal r-mode cluster analysis, presented in Figure 3.2-38, differed from the other cold month monitoring periods in that no assemblage of mud-bottom dwellers of high abundance was present. The Q-mode for this sampling period (Figure 3.2-30), showed a diel separation and the r-mode analysis supports this.

The analysis of variance (ANOVA) for the six most abundant species showed a highly significant temporal distribution for all six species (Table 3.2-18). Only one species Arius felis, showed a significant spatial distribution with the lowest abundance occurring in the southern fringe area (Table 3.2-10) during the 20-week post-disposal monitoring period. Arius felis and Prionotus tribulus both had significant spatial-temporal distributions. The 20-week post-disposal monitoring period was important for both of these species with Arius felis being the numerically dominant vertebrate species, and Prionotus tribulus showing a distinctly higher abundance in the disposal and southern fringe sampling areas.

Length-frequency diagrams, called Hubbsograms in honor of the original authors describing their use (Hubbs and Hubbs 1953) are useful in describing the time course of a series of fisheries collections. This is most useful in describing the overall increase in size of a population of organisms over a season and particularly helpful in discerning recruitment of juvenile organisms into the local populations sampled.

Table 3.2-18. Analysis of variance to determine major influencing factors for the major taxa collected during the fisheries survey.

	SOURCE	F	TAIL. PROB.	SIGNIFICANCE
	MEAN	140.96	0.0000	***
Anchoa mitchilli	PERIOD	9.98	0.0000	***
	STATION	0.39	0.7636	
	PS	0.58	0.8551	
	MEAN	83.10	0.0000	***
Arius felis	PERIOD	82.22	0.0000	***
	STATION	2.75	0.0451	
	PS	2.75	0.0022	**
	MEAN	74.96	0.0000	***
Etropus crossotus	PERIOD	0.86	0.0001	***
	STATION	0.88	0.4512	
	PS	1.67	0.0800	
	MEAN	36.48	0.0000	***
Micropogonias undulatus	PERIOD	21.87	0.0000	***
	STATION	0.94	0.4256	
	PS	0.92	0.5282	
	MEAN	144.92	0.0000	***
Prionotus tribulus	PERIOD	14.31	0.0000	***
	STATION	1.24	0.2990	
	PS	1.93	0.0356	
	MEAN	10.73	0.0013	**
Sphoeroides parvus	PERIODL	3.54	0.0087	**
	STATION	0.80	0.4966	
	PS	0.75	0.6976	

Error Degrees of Freedom = 140 for all species (n=160).

*** = very highly significant difference
** = highly significant difference

The Hubbsogram Figures 3.2-39 through 3.2-44, show the abundance and size distribution, including the standard deviation and the mean, for each of the major vertebrate species presented in Table 3.2-18. Anchoa mitchilli (Figure 3.2-39) showed a small decline in mean standard length from December to February, and then an increase in May. The 52-week post-disposal mean standard length was comparable to that of the previous year. Arius felis (Figure 3.2-40) showed no great variation in mean standard length from the 2-week to 20-week post-disposal monitoring periods, and the abundance increased during the 20-week post-disposal sampling period. Arius felis was not present during the 2-week pre-disposal or 52-week post-disposal sampling periods when water temperatures were lowest. Etropus crossotus (Figure 3.2-41) had a nearly constant mean standard length (SL) of 51.4 -51.9 mm from December to February, and an increase to 82.9 mm SL in May. May was characterized by a size class of 72-97 mm SL except for a single individual of 41 mm SL. Micropogonias undulatus (Figure 3.2-42) showed a distinct drop in abundance during January (2-week post-disposal) and the presence of two distinct size classes are 32-75 mm and 103-120 mm SL. A clear distinction in size class is not apparent during the 20-week post-disposal sampling period, but shows up again during the 52-week post-disposal period with one individual of 23 mm SL separating from the others which ranged between 93 and 118 mm SL. Prionotus tribulus (Figure 3.2-43) demonstrates a continual increase in mean standard length from the 2-week pre to the 20-week post-disposal monitoring periods with the population in February having a size range of 23-52 mm and one individual of 70 mm SL. The mean standard length increased to 63.2 mm during the 20-week post-disposal monitoring period. The 52-week post-disposal monitoring period again showed a lower mean standard length of 35.3 mm. Sphoeroides parvus (Figure 3.2-44) showed a decrease in the mean standard length during the 20-week post-disposal monitoring period from the previous monitoring periods. This decrease was due to the presence of a highly varied size range of 22 to 84 mm SL. The mean standard length increased to 49.3 during the 52-week post-disposal sampling period.

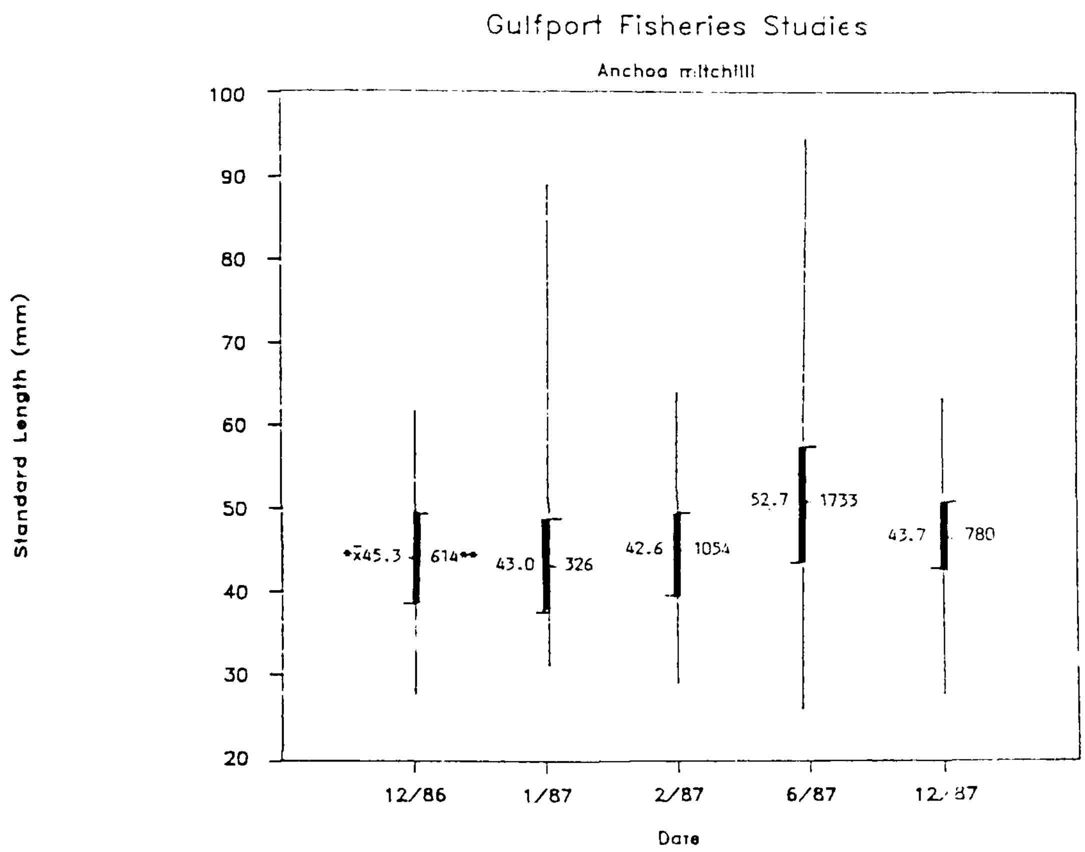
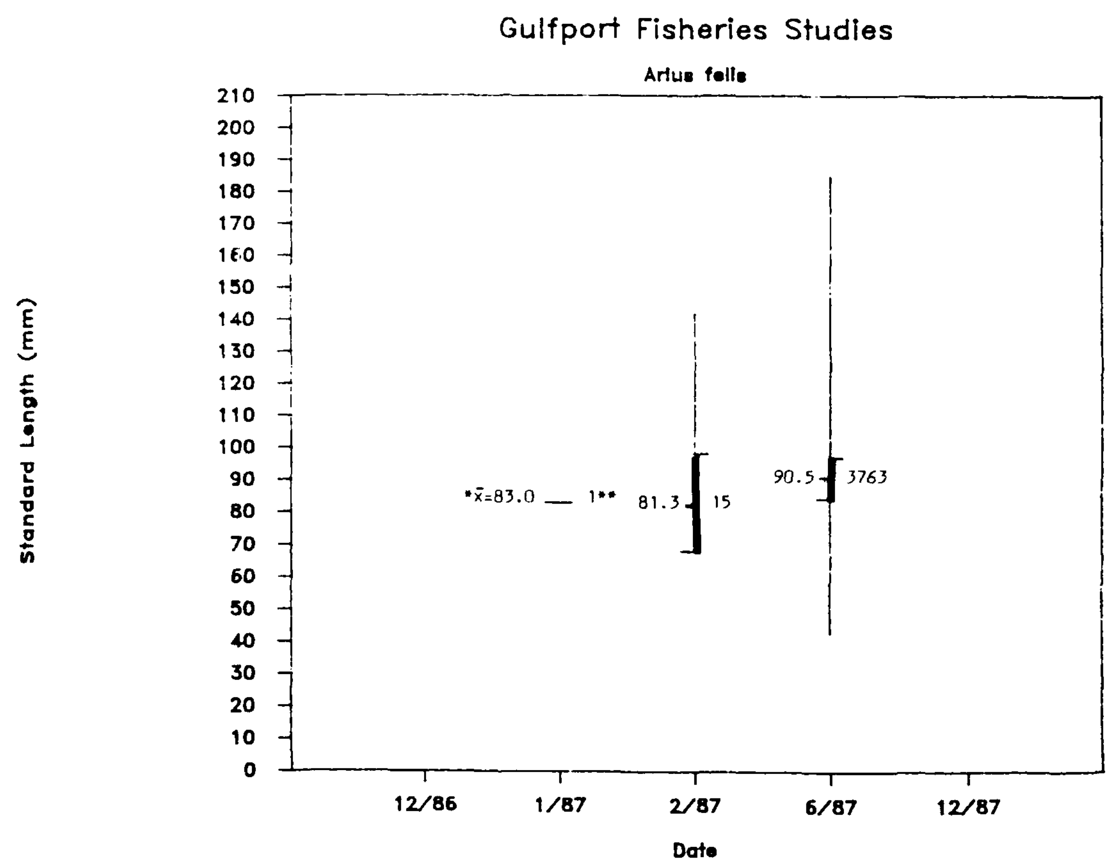
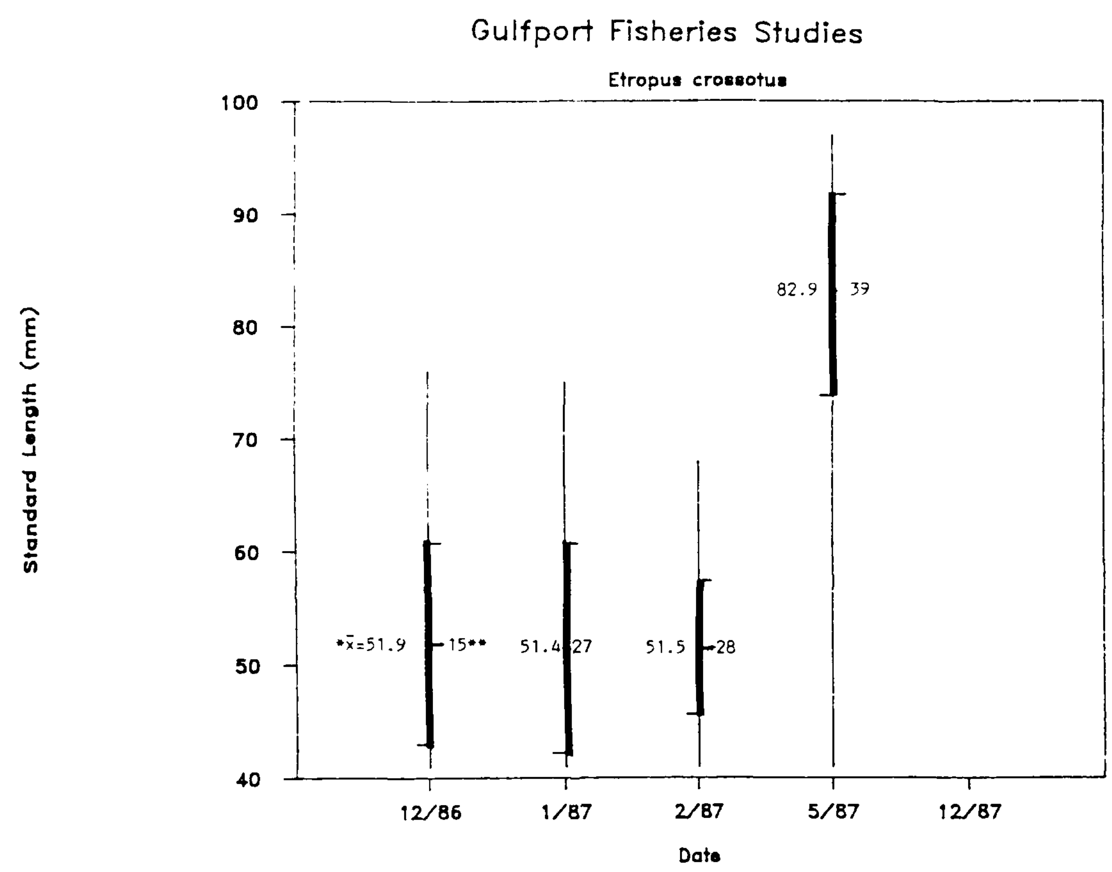


FIGURE 3.2-39 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR ANCHOA MITCHILLI.



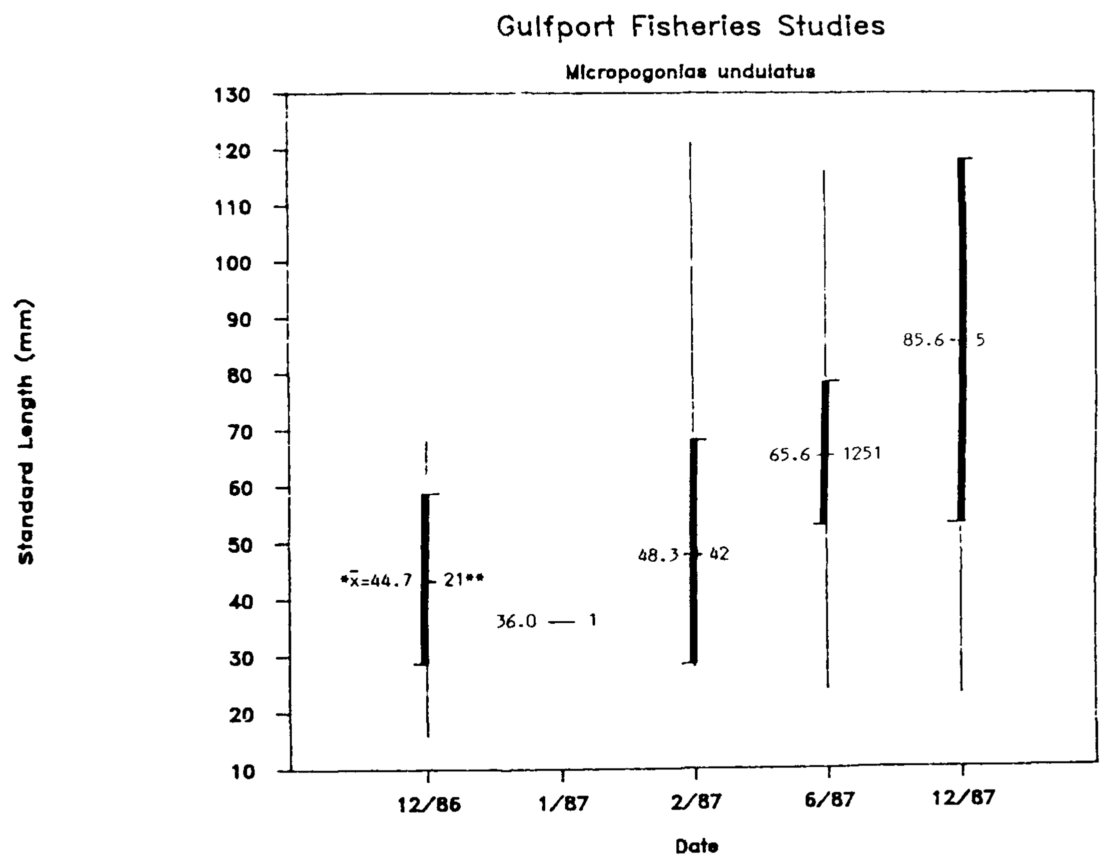
* Mean standard length (SL).
** Total number of individuals collected.

FIGURE 3.2–40 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR ARIUS FELIS.



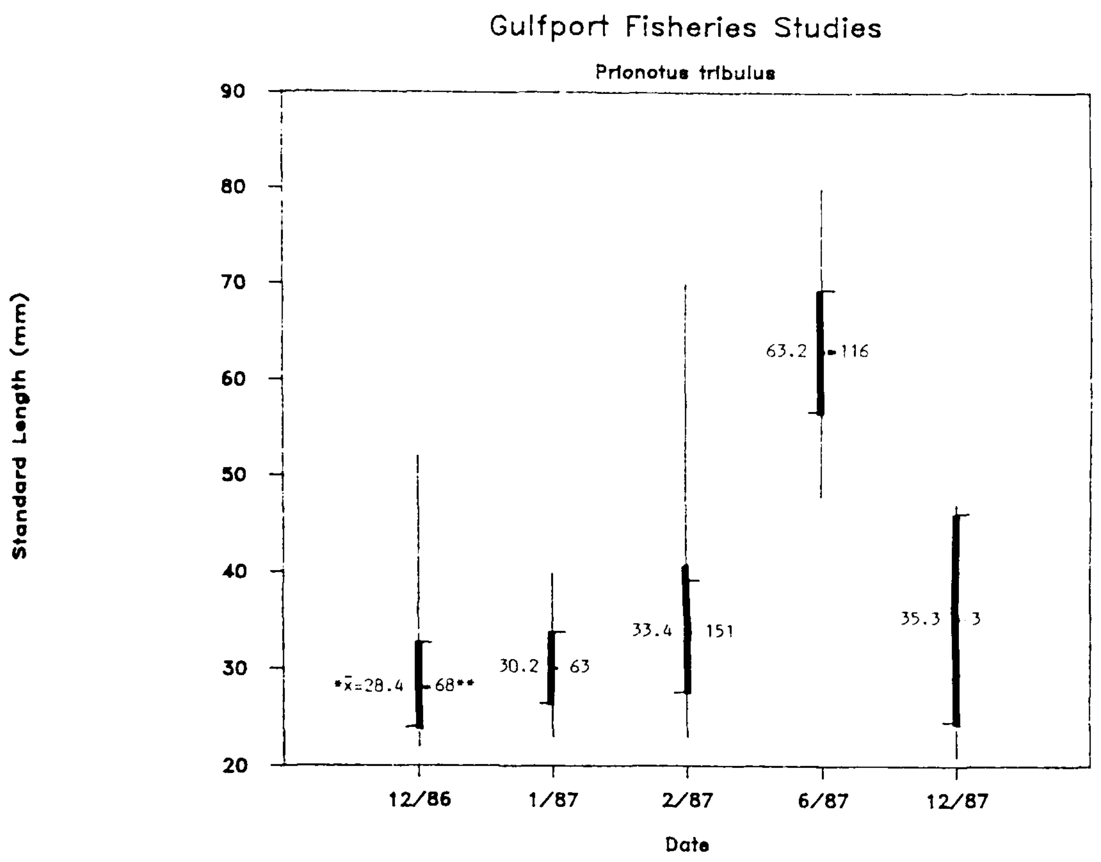
* Mean standard length (SL).
** Total number of individuals collected.

FIGURE 3.2-41 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR ETROPUS CROSSOTUS.



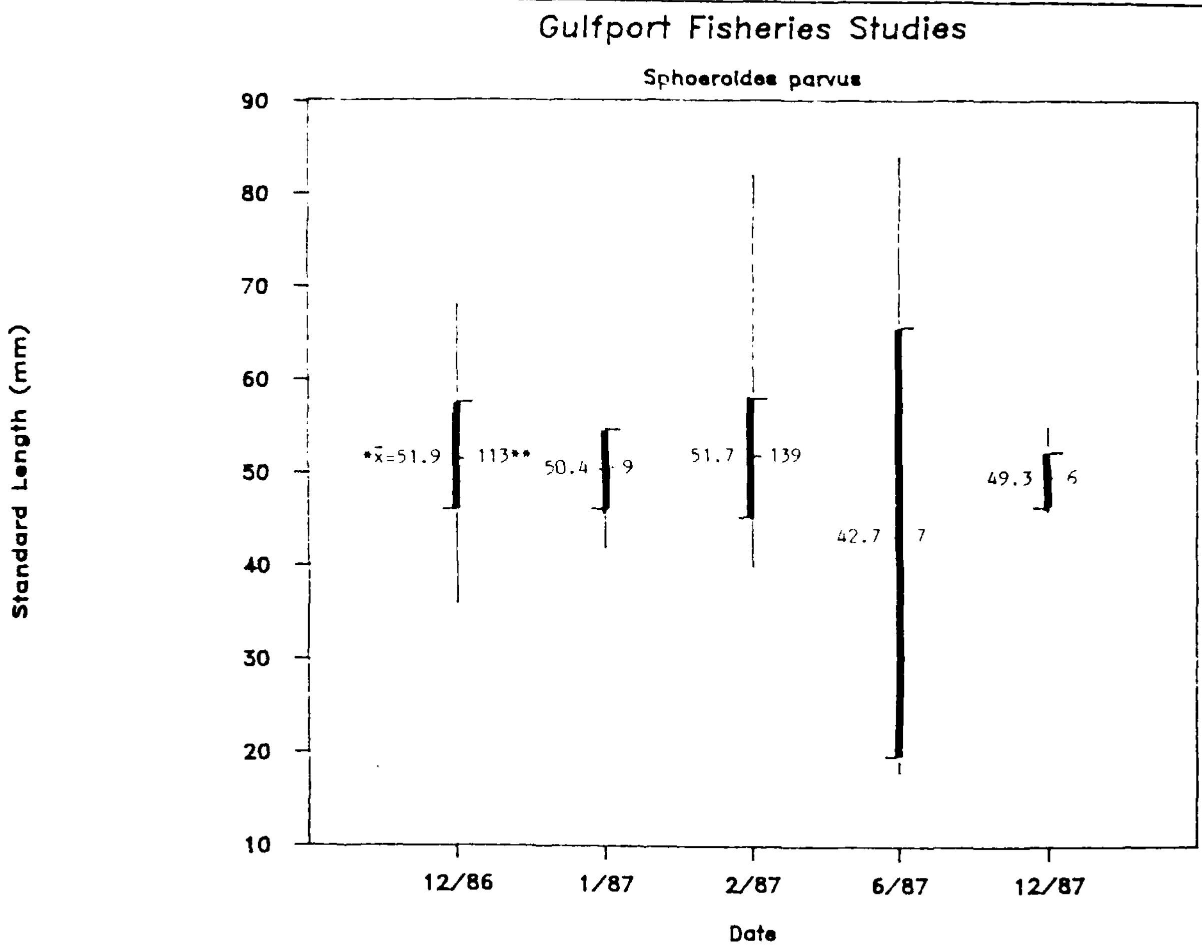
* Mean standard length (SL).
** Total number of individuals collected.

FIGURE 3.2-42 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR MICROPOGONIAS UNDULATUS.



* Mean standard length (SL).
** Total number of individuals collected.

FIGURE 5.2-43 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR PRIONOTUS TRIBULUS.



* Mean standard length (SL).
** Total number of individuals collected.

FIGURE 3.2-44 HUBBSOGRAM OF LENGTH FREQUENCY AND ABUNDANCE DATA FOR SPHOEROIDES PARVUS.

4.0 DISCUSSION

4.1 PHYSICAL / CHEMICAL ENVIRONMENT

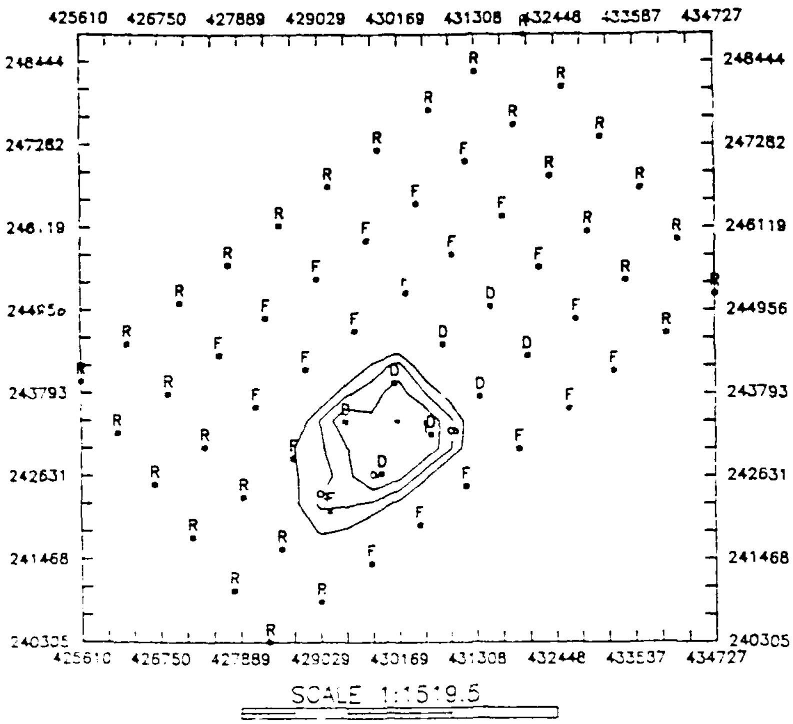
4.1.1 Bathymetry

Results of the four bathymetric surveys conducted at the Gulfport Ship Channel open water dredged material disposal site showed definite areas of sediment deposition within both the disposal and fringe areas. The area of greatest deposition was located within the disposal area, with a maximum sediment rise of less than 1 ft.

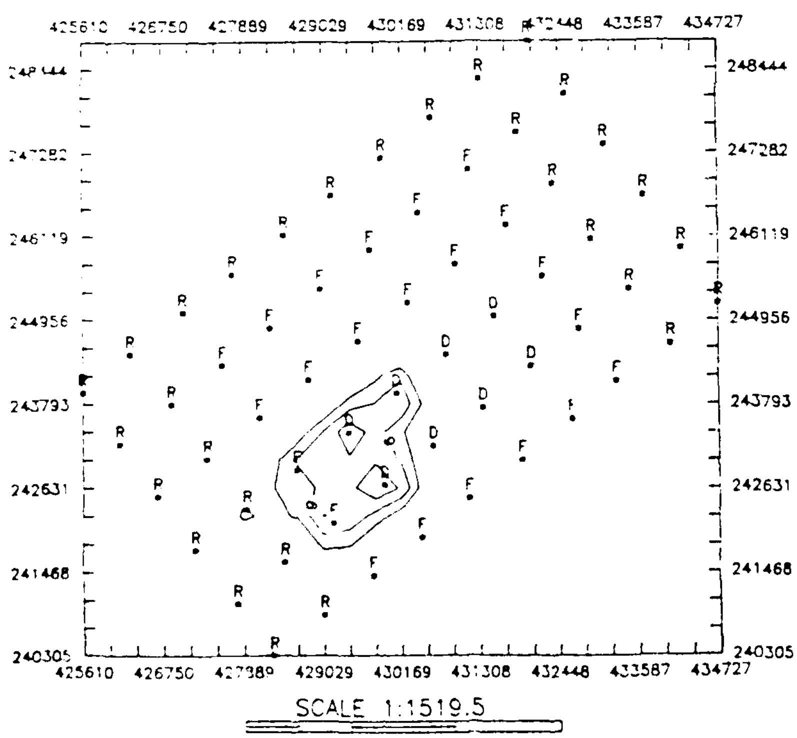
Determination of the volume and areal extent of the area of sediment deposition with a rise of 0.5 ft or greater was determined based on the difference in depth between the predisposal and 2-week post-disposal surveys. A total of 61,385 yd^3 was deposited by the dredging contractor in his report. Based on bathymetry a calculated volume of 80,900 yd^3 of sediment covering an area of 514,000 yd^2 was deposited within the overall study site. The reported versus calculated differences is explainable by dredged material bulking. Eighty-six percent (69,800 yd^3) of the calculated total volume of sediment deposited with a rise of 0.5 ft or greater was located within the disposal area. Fourteen percent (11,000 yd^3) of the total volume of deposited sediment was located within the fringe area. Eighty-five percent of the areal extent of the sediment mound was located within the disposal area, with the remaining 15 percent within the fringe area. These numbers corresponded well with the location and depth of the dredged materials as determined by sediment profile photography (Figure 4.1-1).

Results of the 6-week and 20-week post-disposal bathymetric surveys showed a gradual decrease in both the areal and volumetric extent of the sediment mound with time. The sediment mound identified during the 6-week post-disposal survey contained 50,500 yd^3 (62 percent) less sediment than during the 2-week post-disposal survey. The areal extent of the sediment mound decreased by 285,000 yd^2 (55 percent) during the same time period. Results of the 20-week post-disposal bathymetric survey show the sediment mound created by the thin-layer dredge disposal operations to be nearly undetectable.
Ninety-five percent (76,600 yd^3) of the total volume of the sediment deposited during disposal operations was found to have been dispersed during the 20-week post-disposal survey. The areal extent of the sediment mound (0.5 ft or

2 Weeks Post Disposal



6 Weeks Post Disposal



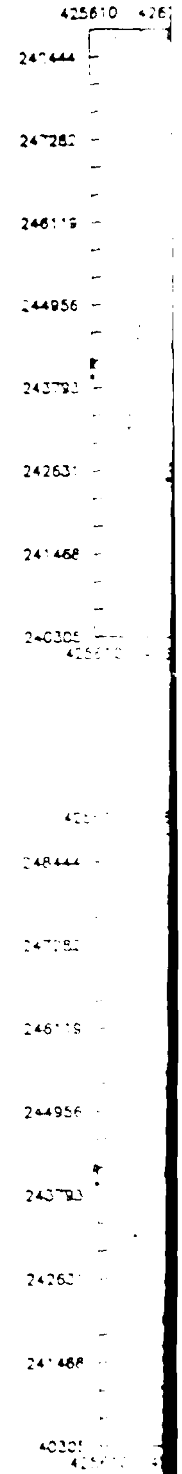
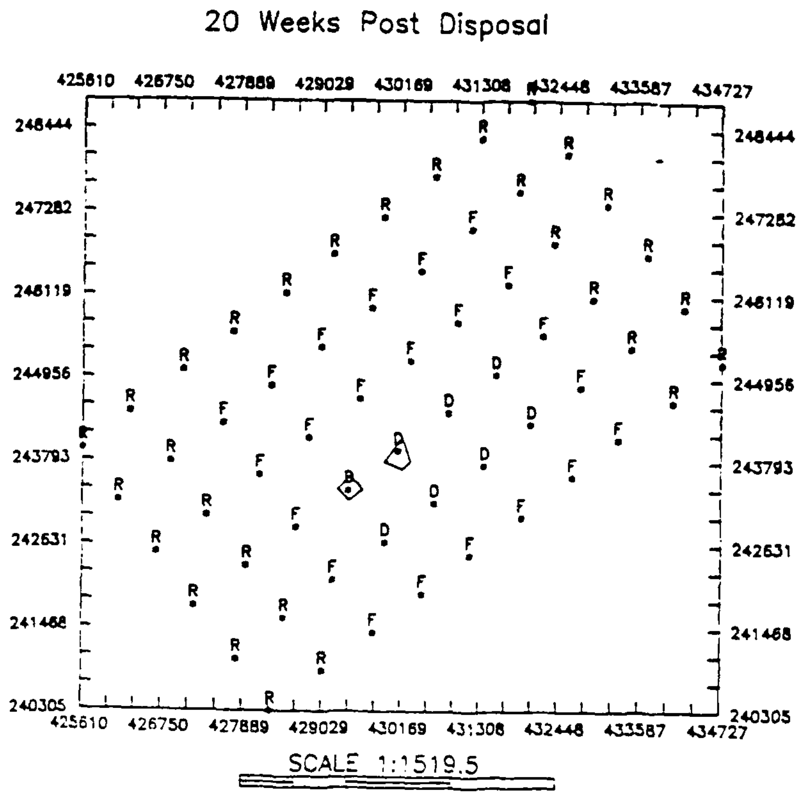


FIGURE 4.1–1. LOCATION OF DREDGE[...] OVERBURDEN BASED ON VERTICAL SE[...] PROFILE IMAGERY. DEPTH OF DREDGE[...] CENTIMETERS.



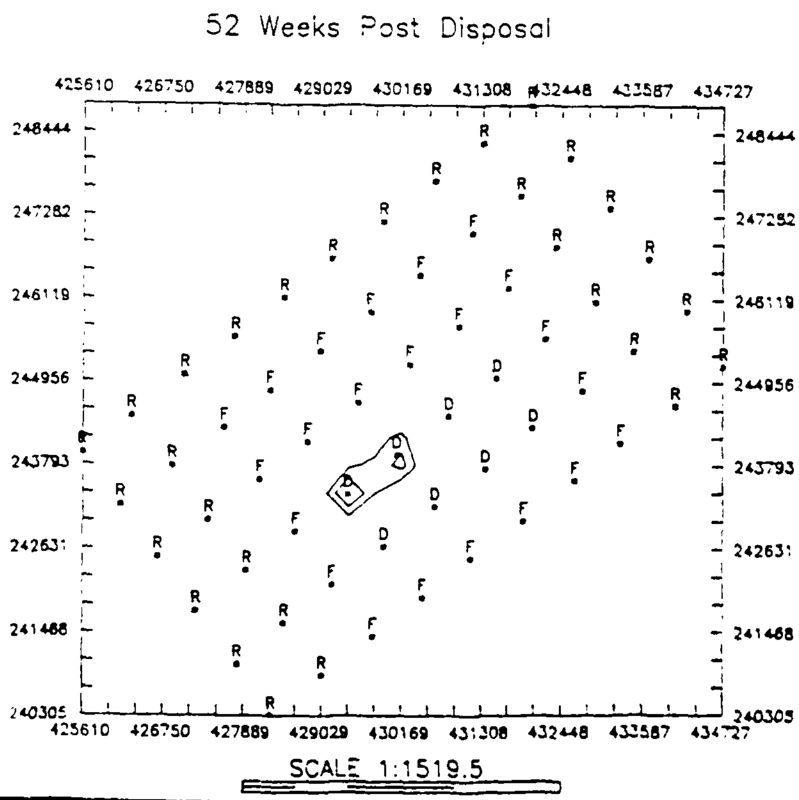


FIGURE 4.1-1. LOCATION OF DREDGED MATERIAL OVERBURDEN BASED ON VERTICAL SEDIEMENT PROFILE IMAGERY. DEPTH OF DREDGED MATERIAL IN CENTIMETERS.

greater) during the 20-week post-disposal survey was 26,000 yd^2. This represents a net decrease of 488,000 yd^2 (95 percent) between the 2-week and 20-week post-disposal surveys.

Results of the four bathymetric surveys show the thin-layer dredged material disposal methodology employed at the Gulfport Ship Channel open water disposal site was effective in achieving a sediment rise of less than 1 ft in the disposal area. Ninety-five percent of the sediment mound with a rise of 0.5 ft or greater was found to be dispersed within 20 weeks following completion of disposal operations. The observed dispersal of sediments was likely due to wave-induced turbulence at the disposal site. Evidence for this presumption is given below.

The vertical sediment profiling results conclusively show the placement of the dredged materials at the Gulfport Harbor study site (Figure 4.1-1). The 2-week post-disposal sediment profile survey indicated a dredged material depth of 13 to 15 cm at stations 4-4, 4-5, 5-4 and 5-5 with the sediment tapering off to the southwestern quadrant. The material was still detectable at a thickness of up to 14 cm 6-week post-disposal. In addition there was an indication that the material was moving to the southwest since the depth of the material had increased at stations 4-2 and 4-3 from the 2-week to the 6-week survey. By the 20-week survey, the dredged material was only detectable at 4 stations to a maximum depth of 7 cm. By the 52-week sampling, dredged materials were present only at stations 4-4 and 4-5.

The results of vertical sediment profile imaging corroborated the results of the bathymetric survey that indicated a loss of materials (Figure 4.1-1). The dredged materials declined in both depth and spatial coverage from the 2-week post-disposal survey through the 6-week, 20-week and 52-week post disposal efforts. For example, at one grid station (WE-5-5), a positive signature of the dredged material (>15.2 cm) was present in the 2-week image, 4 cm of dredged material was observed in the six week image and at twenty weeks post-disposal there was little evidence of any dredged material in the images. At 52-weeks post-disposal, the dredged material signature was recognizable but had lost much of its distinctiveness.

The signature of deposited materials as detected by analysis of the vertical sediment profile images slowly disappeared with time, presumably due to physical and biological reworking of the sediments (see Plate 3.1-3). The material was only detectable at two stations (4-5 and 4-6) during the 20 and 52-week post disposal surveys. It should be noted that the dredged materials detected during the 52 week post-disposal survey had been extensively "weathered" and modified by biological activity. From this evidnece, the activity of bioturbation was a significant factor in trems of system recovery following dredged material disposal.

Based on the imagery, the decline of the dredged materials could be attributed to both physical loss (erosion) of the materials and biological reworking (mixing with underlying sediments). The appearance of mud lumps and casts were indicative of large scale physical activity in the area.

The only other sediment profile parameter that changed was the depth of the RPD which showed a slightly shallower depth 2-week post-disposal. All other surface and subsurface features were similar throughout the study.

4.1.2 Water Quality

Ambient water-quality conditions in the study area during the predisposal water-quality survey were highly uniform at all stations. DO concentrations were relatively high at all stations and depths, with individual values ranging from 7.8 to 10.4 mg/L. Water temperature was typical for the winter months, with values ranging from 12.0 to 13.0°C. Salinity demonstrated little variability and averaged 21.9 ppt in the study area. Total suspended solids measured during the predisposal survey ranged from <5 to 74 mg/L.

Results of the predisposal water-quality survey indicate the water column in the study area is highly mixed and typical of near-shore conditions.

4.2 BIOLOGICAL RESOURCES

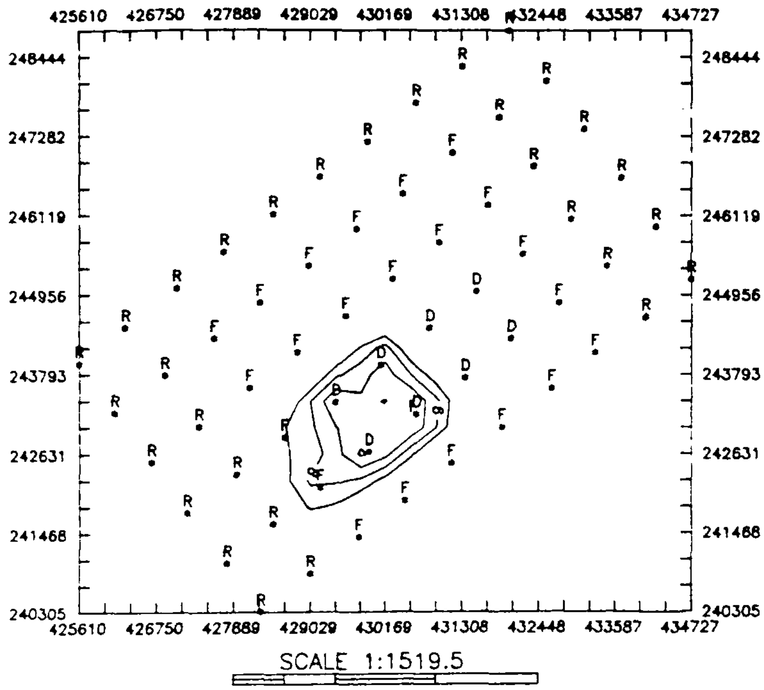
4.2.1 Benthic Macroinfauna

Organism abundance for the 2-week predisposal period showed a diverse community throughout the study area with the number of organisms generally in the range of 2-3000 organisms $-m^{-2}$. Dominant taxa included the polychaetes Armandia maculata, Podarkeopsis levifuscina, Sigambra tentaculata, and Paramphinome pulchella, the brittlestar Micropholis atra, the hemichordate Balanoglossus c.f. aurantiacus and Rhynchocoela. The number of taxa per grab averaged about 25 during the predisposal period, the highest during the five sampling periods.

Abundance of organisms during the 2-week and 6-week post-disposal samplings and the corresponding dredged material overburden for comparison is presented in Figure 4.2-1. The organism abundance contours in this figure were adjusted to show only abundances of less than 1500 organisms-m^{-2}. While much of the surrounding area remained in the 2-3000 organisms $-m^{-2}$ range, stations in the disposal area and two of the south-west fringe stations had less than 1000 organisms $-m^{-2}$. This was a highly significant difference in abundance and could be directly attributable to the disposal operation. By the 6-week post-disposal period the abundances had recovered somewhat in that only two of the impacted stations had less than 1500 organisms $-m^{-2}$ (Figure 4.2-1). The 20-week and 52-week post-disposal abundances (see Section 3.2.1) had returned to the predisposal levels of 2-3000 organisms $-m^{-2}$.

In terms of the number of organisms per sample, a trend similar to the decrease in abundance was noted (Figure 4.2-2) The 2-week post-disposal survey shows a depression in the number of taxa at the same stations that exhibited the low abundances (Figure 4.2-1). By the 6-week post-disposal monitoring period, the number of taxa had returned to values more similar to the reference stations. By the 20-week post-disposal survey the disposal stations could not be distinguished from the other stations sampled.

The findings in the spatial analysis of the data are corroborated by the ANOVA and the cluster analyses. In all cases, the 2-week post-disposal stations 4-3, 4-4, 4-5 and 5-3 were separated from the other stations sampled. This indicates that a distinct community shift was noted in the impacted stations, 2 Weeks Post Disposal



6 Weeks Post Disposal

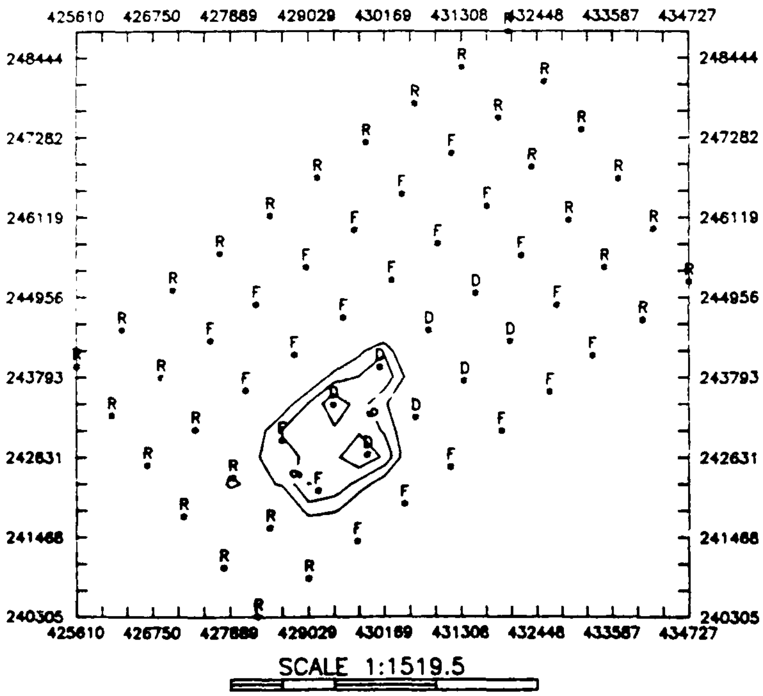
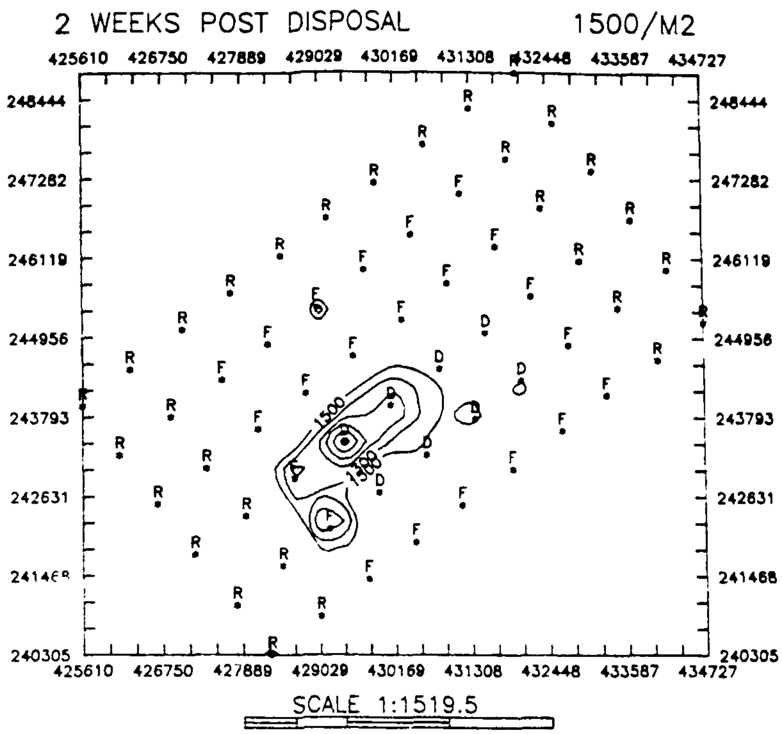


FIGURE 4.2-1. COMP
LOCATION AND MACRO
6-WEEK POST-DISPOS
DM IN CM.; ABUN. IN



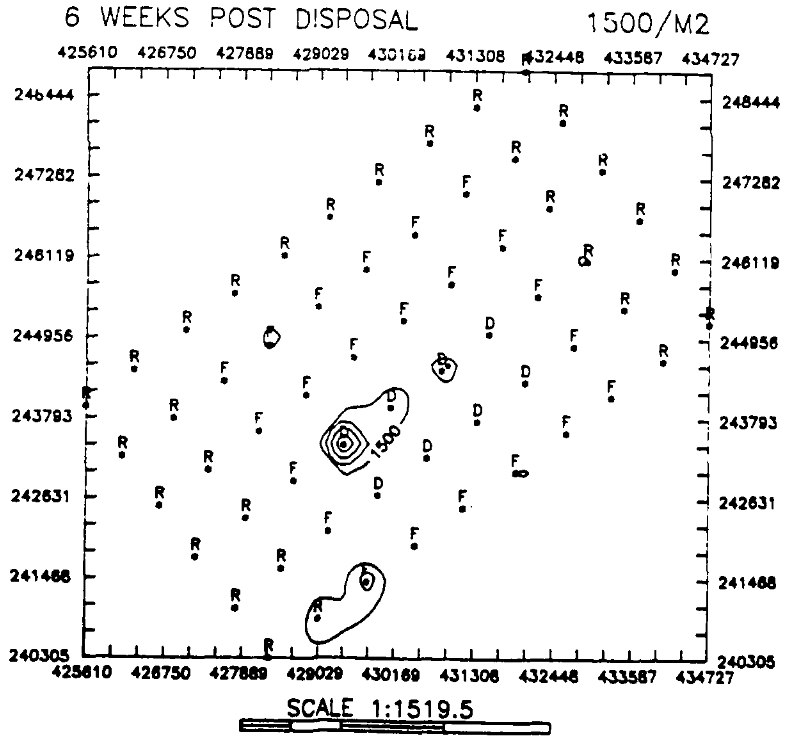


FIGURE 4.2-1. COMPARISON OF DREDGED MATERIAL LOCATION AND MACROINFAUNA ABUNDANCE, 2- AND 6-WEEK POST-DISPOSAL.
DM IN CM.; ABUN. IN #/M2.

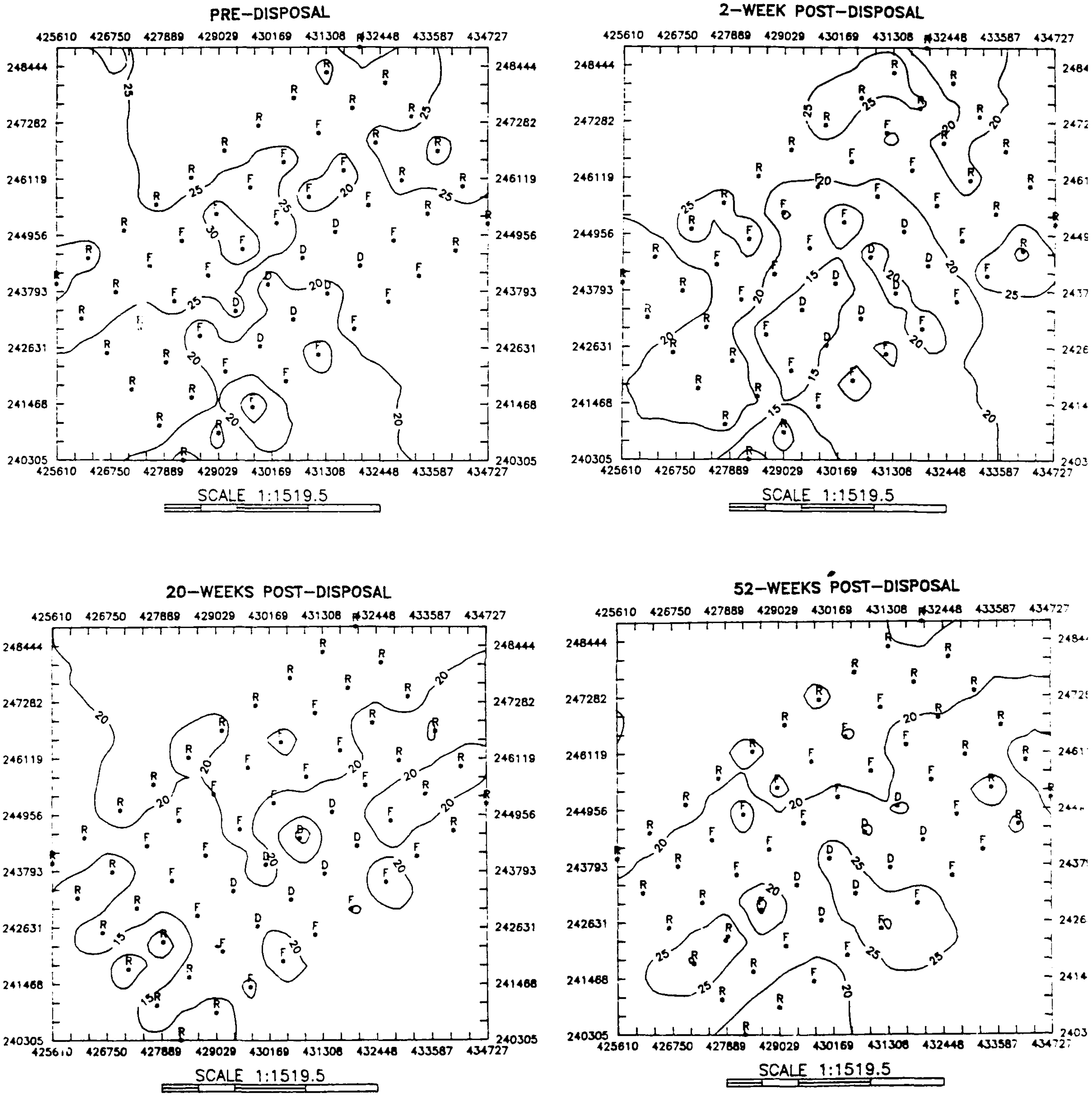
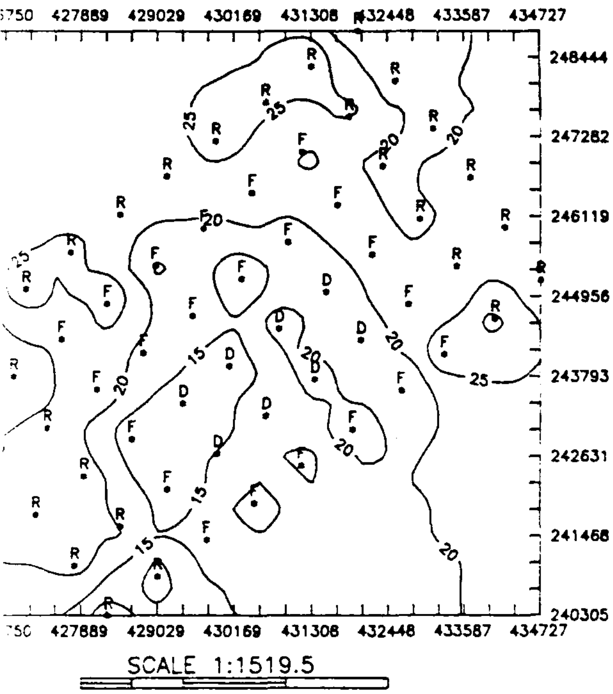
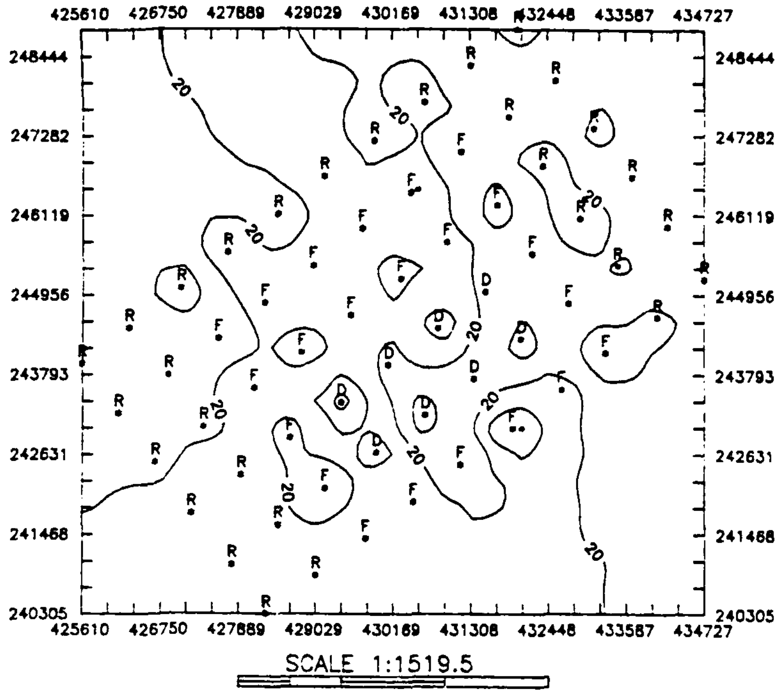


FIGURE 4.2-2. NUMBER
DURING THE GULFPORT

2-WEEK POST-DISPOSAL



6-WEEKS POST-DISPOSAL



52-WEEKS POST-DISPOSAL

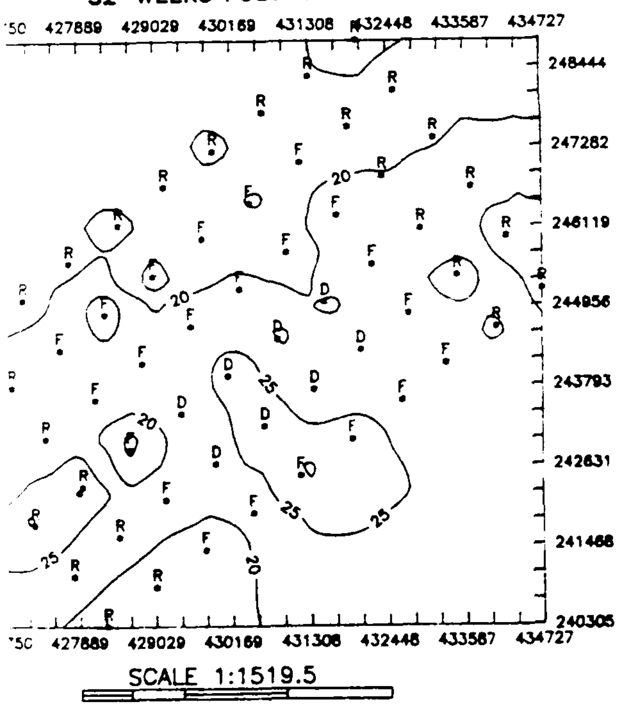


FIGURE 4.2-2. NUMBER OF MACROINFAUNA SPECIES DURING THE GULFPORT STUDY.REPORTED IN #/CORE.

presumably because of the change in abundance of several taxa (most notably *Armandia* and *Mediomastus* which were important in overall community composition.

The decrease in abundance and species composition was also parallelled by a decrease in macroinfauna biomass which showed a distinct decline in the disposal area during the 2-week post disposal sampling effort. Some recovery in total biomass was noted by the 6-week post-disposal sampling but the disposal site stations did not return to levels seen at the surrounding stations until the 20-week period.

Based on these findings, it is reasonable to conclude that the dredged material was primarily discharged in an area bounded by the stations 4-3, 5-3, 4-5 and 5-5. Since this includes two stations in the southwestern fringe area it is likely that the majority of the material disposed was probably not in the direct center of the disposal area as depicted in this study but was mostly discharged on the southwestern part of the disposal area. There was no dredge material detected in the northeastern most portion of the disposal area. This observation would suggest that the random station sampling may not be sufficient to detect a biological impact within the disposal area since it included both impacted and unimpacted stations and the impacts were averaged out. This suggestion is supported by the results of the random station ANOVA which showed no significant differences between experimental strata. Since the inclusion of the random sampling was primarily to observe sampling variability and adequacy in terms of single box-core sample, the sampling did serve a valuable role in the study. Additionally, it should be noted that the fixed station sampling more than adequately detected the impacts from the disposal event.

Based on the results of recruitment sampling, no large scale recruitment events occurred immediately following the disposal operation. Overall, based on both recruitment and vertical sediment imagery, the recruitment of organisms into the dredged materials was dominated by adult migration or adult survival, followed by a strong pulse of spring recruitment the following spring. Subsurface activity immediately following the disposal event appears to have slowed primarily due to seasonal temperatures.

In terms of abundance of individual taxa, all species tested, except for the polychaete _Sigambra tentaculata_, showed significantly lowered abundances at the disposal stations. This indicates that except for pioneering types of taxa, all macroinfauna were equally affected by the material discharge. This implies that impact was of a physical nature since there was no selectivity in terms of reducing certain community members. This is supported by the Q-mode cluster analyses in that there were no large scale community shifts in terms of selective impacts to individual species as a result of the discharge.

Sediment profile photography also indicated that there was a transient shift in the community as a result of the disposal operation. The study area was characterized as a late Stage II - Stage III community during the predisposal effort. The 2-week post-disposal survey showed some areas impacted by the disposal operation to be of early Stage I type community and others to be late Stage I to Stage II based on the amount of burrowing activity. Even during the 2-week post-disposal sampling there were signs of advanced recolonization at some of the dredge material sites. These observations are suggestive of an upward migration of the larger fauna. It should be emphasized that no azoic (devoid of organisms) areas were found.

The community at Gulfport Harbor is an advanced Stage II to Stage III community. Several large tube-dwelling and head down feeder organisms were collected including several brittlestar and holothurians. These organisms are known for their intense burrowing behavior which probably contributed to the rapid recovery and reworking of the dredged materials due to some upward migration through the thin layer of dredged material.

4.2.2 _Demersal Organisms_

The abundance of demersal fisheries organisms, as seen in Table 3.2-10, followed distinct seasonal trends. This can be illustrated with _Arius felis_ had very low abundances or absent during cold month monitoring periods, but being the numerically dominant vertebrate during the 20-week post-disposal sampling period in May. _Anchoa mitchilli_ was the only species present in high numbers during all monitoring periods. Several other discernable trends were also present. _Etropus crossotus_ and _Prionotus tribulus_ had a constant presence during the first four monitoring periods, but were nearly absent during the 52-

week post-disposal sampling period. This sampling period corresponded to a period of very cold weather which caused a drop in water temperature and is very possibly the reason for their absence. This trend was also noted in the macroinfauna community in terms of a species shift noted during the same period. Thus, from these observations it can be concluded that the shift in species noted during the 52-week sampling in both the macroinfauna community and the demersal organisms could be attributed to adverse hydrographic conditions.

Another trend is seen in Micropogonias undulatus and Sphoeroides parvus, species which displayed obvious decreases in abundance during the 2-week post-disposal monitoring period. However, another species, Penaeus setiferus, showed no obvious decrease in abundance in the post-disposal monitoring periods until its expected decrease during the warm weather monitoring period.

Along with the variability in abundance, a corresponding change in the number and composition of taxa collected was also noted, (Tables 3.2-13 through 3.2-17). This and the analysis of variance (Table 3.2-18), support the importance of the temporal influence. The ANOVA table also demonstrates that a significant spatial influence was present for only one of the six numerically dominant vertebrate species. This significance is attributable to the 20-week post-disposal collections of Arius felis (Table 3.2-16), which showed a distinct trend in abundance from the shallowest most-northerly reference area to the deeper southern fringe area. The trend does not indicate a distinct avoidance of the dredged material disposal area. In addition to these observations and statistical analyses, the cluster analysis for each of the monitoring periods (Figures 3.2-26 through 3.2-30) shows a closer linkage of the disposal area to the northerly reference area or northern fringe area than to the southern fringe area. The 20-week post-disposal monitoring period is a notable exception. The linkage of the disposal and southern fringe areas during the 20-week post-disposal sampling period, however, is due to the previously mentioned decrease in abundance seen in these areas by the dominant species Arius felis. Figure 4.1-1 shows a southerly position of the disposal area and a general southwesterly movement of the dredged material. While it may be tempting to draw a conclusion of an obvious dredged material influence from these data, it must be remembered that the linkage of the disposal area to the more northern treatment areas occurred during the pre-disposal as well as post-disposal monitoring periods. Also, the dominant vertebrate species during four monitoring periods was a non-demersal planktivore Anchoa mitchilli, which is probably a poor species for indicating sediment impacts. In addition, the demersal invertebrate species Callinectes sapidus, Penaeus setiferus and Squilla empusa display no decrease in abundance in the disposal or southern fringe areas (Table 3.2-12) during any of the post-disposal monitoring periods. This is not confined to benthic invertebrates as Figures 3.2-34 through 3.2-36 show tight groupings of these invertebrate species with bottom-dwelling vertebrates. This observation is in contrast to the macroinfauna community which showed a distinct reduction immediately following the disposal operation. Thus, the larger more mobile demersal species may have moved back into these areas immediately following the discharge of materials.

The Hubbsograms, Figures 3.2-39 through 3.2-44, show an increase in mean standard length over the course of the first three post-disposal monitoring periods for five of the six major fish taxa. This indicates a growth period correlating to warming temperatures. Only Sphoeroides parvus decreased in mean standard length in May due to the presence of a highly variable size range. This is probably due to the addition of a new year class to the existing population. The presence of a new year class can also be seen in Micropogonias undulatus with the first year class ranging from 32-75 mm SL and an older year class of 103-121 mm SL. The small size of Prionotus tribulus during the first three field efforts seems to indicate that juveniles of this species winter within estuarine areas. Their large increase in standard length again shows a distinct growth period before the advent of late spring and summer spawning (Williams, 1983). The presence of juvenile and first year class individuals within the monitoring area seems to indicate that it was not avoided as a nursery area and that no adverse effect of dredged material disposal on younger stages of the life cycle was present.

It is clear from all the presented data that there is a strong natural temporal influence on the fisheries resource within this shallow estuarine area. The disposal of new work dredged material within the monitoring area showed no short-term impact of a magnitude approaching the natural seasonal events. The presence of a short-term impact on certain species, notably Micropogonias *undulatus* and *Sphoeroides parvus*, however, did seem to be indicated. The data collected and presented show that no significant impact occurred on the fisheries resource as a whole, and no changes in utilization of the disposal area appeared to have taken place.

5.0 CONCLUSIONS

Based on the results of the bathymetric survey, the benthic invertebrate sampling and the vertical sediment profiling, dredged material was disposed i an area bounded by stations 4-3, 5-3, 4-6 and 5-6. The depth of the material was between 6 - 12 inches based on the precision bathymetry and slightly greater than 6 inches (> 15 cm) based on sediment profiling. The materials were detectable during the 6-week post-disposal monitoring period by both precision bathymetry and vertical sediment profiling, but were almost undetectable at many disposal stations by the 20-week post-disposal survey. The observation further indicated that the sediments were being transported in a southwesterly direction.

Impacts to the benthic macroinfauna community was observed in terms of lowered abundances (< 1000 organisms $-m^{-2}$ versus 2-3000 organisms $-m^{-2}$) and slightly lower numbers of species (<15 versus 25) at the stations directly impacted by the dredging operation. This observation was corroborated with the biomass data and the vertical sediment profile images in terms of successional stages of the benthos. By the 6-week post-disposal survey, some recovery of the benthic animals was observed in both an increase in the numbers and kinds of organisms at the disposal site. By the 20-week post-disposal survey, no differences between the disposal, fringe or reference sites could be detected. This recovery paralleled the disappearance of the materials observed by the bathymetric data and the sediment profile imagery. In part, the disappearance of the material could be directly attributable to the biological reworking of the dredge materials, incorporating them with the underlying sediments. However, evidence of large scale physical events were noted in the vertical sediment profile images in terms of mud clasts and lumps of presumably physical origin.

Recovery of the area in terms of the macroinfauna was primarily mediated by rapid adult migration into the area and some survival and subsequent migration through the disposed materials. No large scale larval recruitment was noted but this was due more perhaps to seasonal factors since the recovery occurred through the winter months.

The impacts of the new work dredged material disposal appear to have been confined to a limited portion of the fisheries resource, namely *Micropogonias undulatus* and *Sphoeroides parvus*. This impact was short-term as populations that were noticeably low during the 2-week post-disposal monitoring period had returned by the 6-week post-disposal monitoring period. There was no observable impact on the fisheries resource as a whole, either short or long term. This reflects the differences in the community types of the benthic macroinfauna and fisheries resource populations. The relatively sessile benthic population displayed more sensitivity to the area-limited perturbation of thin-layer disposal in terms of a reduction in the abundance of some of the major taxa, total number of organisms, number of species and in total biomass. This impact was temporary and within 20 weeks after the material disposal the macroinfauna community had recovered so that the impacted area was no longer distinct from the surrounding reference and fringe areas.

This report has answered several questions concerning the disposal of dredged material using the "thin-layer" methodology. Based on the bathymetry portion of this study, we determined that the operation was successful in obtaining a "thin-layer" of dredged materials to a nominal 6-12 inches of overburden. The areal extent of the overburden was directly measured. Direct changes in sediment and benthic community characteristics were observed following dredged material disposal. Within 20 weeks post-disposal, the benthic community had returned to levels observed during the predisposal sampling. Direct observation of the dredged material was noted 52-weeks following disposal but only in a small portion of the disposal area and the materials had been extensively "weathered" by physical and biological reworking. No changes were observed to have taken place in the utilization of the area by fisheries resources.

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